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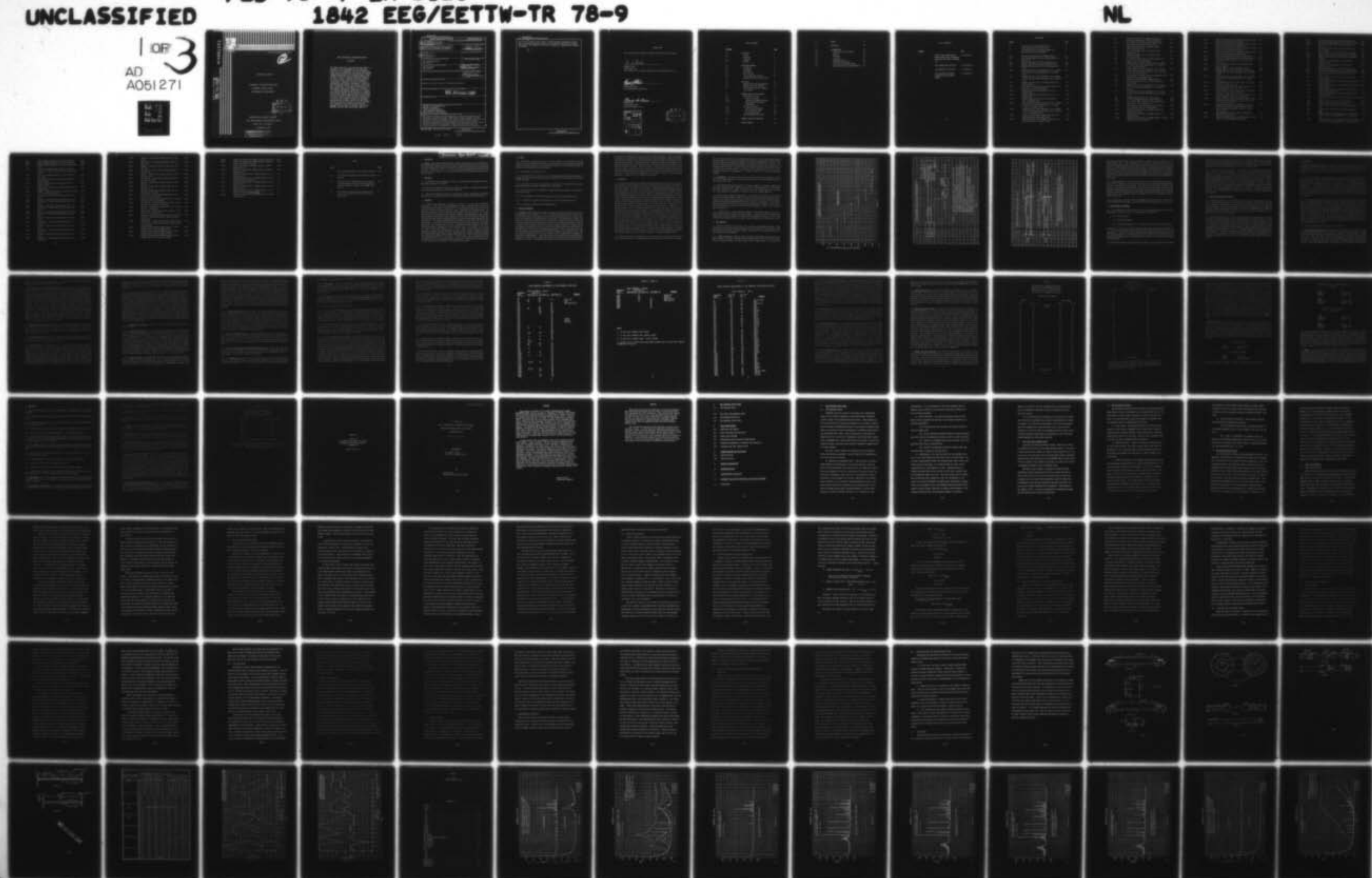

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1842 EEG/EETTW TR 78-9

TECHNICAL REPORT

FREQUENCY DIVISION MULTIPLEX BASEBAND CABLE PLANT PERFORMANCE IMPROVEMENT

TRANSMISSION SYSTEMS BRANCH

1842 ELECTRONICS ENGINEERING GROUP

SCOTT AFB, ILLINOIS

1 FEBRUARY 1978

1842 ELECTRONICS ENGINEERING GROUP

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GROUND LOOP NOISE AND CROSSTALK

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides an in-depth discussion of the noise problems that are encountered in existing Defense Communications System frequency division multiplex baseband cable plants. The causes of these problems are cited; test procedures to isolate and identify specific deficiencies are provided. Corrective techniques and their application for the reduction of noise within existing facilities are described. Often quoted (but unsuccessful in practice) methods for reducing RFI in TRIAX cable plants are discussed in

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20. (Cont'd) terms of test results, System degrading measurement methods used to accomplish baseband sweeps and read baseband loading are disclosed. And finally, the economics of recovery of logged out communications channels is treated,

APPROVAL PAGE

This report has been reviewed and is approved for publication and distribution.

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1.0 INTRODUCTION

1.1 General. Radio frequency interference (RFI), crosstalk and ground loop noise in baseband cable plants interfacing frequency division multiplex (FDM) and wideband communications radios is depriving the Defense Communications System (DCS) of hundreds of communications channels while degrading the performance of thousands of others. This report discusses the fundamental characteristics of FDM baseband cable plants currently in use, details their deficiencies and describes the technology for their correction.

1.2 References.

1.2.1 AFCS/EPZ Report dated 5 September 1975, Subject: Scope Communications Baseband Cable Plants-Engineering, Installation and Testing.

1.2.2 AFCS-1839 E-I GP-EMC-75-59 Report dated 1 December 1975, Subject: Interference Investigation to AN/UCC-4 Multiplex Equipment at Selected Scope Comm Sites.

1.2.3 AFCS-1839 E-I GP-EMC-77-52 Report dated 15 August 1977, Subject: Radio Frequency Interference Measurements of the New Wideband Cable Plant at RAF Croughton and RAF Uxbridge, United Kingdom.

1.3 BACKGROUND

1.3.1 Baseband cable technology is believed by the author to be a new area of engineering investigation. In past times, installing connectors on a pair of cables and using the cables to interface multiplex equipment and radios seemed to be a straightforward enough task. What could go wrong with the cables if the connectors were on right? Nothing much was the standard answer. The radios and the multiplex and, yes, those poor station grounds were the bad fellows. Not to forget RSLs which were often low enough to justify any noise problems. Then something went wrong. Suddenly high performance radios along with high performance multiplex were being installed in Europe under the Task 21 Scope Comm Program by contractor personnel. The basic systems engineering was good; RSLs were excellent. Yet, the system performance was unacceptable in terms of RFI, crosstalk, and idle channel noise. The contractor correctly identified the problem as poor isolation in the baseband cable plants, but incorrectly laid the fault to GFE-balanced baseband composite video cables. AFCS/EPZ was tasked to investigate and correct these cable plants. The findings are cited in Ref 1.2.1 which is included in Appendix A of this report. From this start grew a new technology consisting of theory, evaluation techniques, and test methods. New test equipment and recent applications engineering has resulted in major improvements in the testing and evaluation of baseband cable plants with increased accuracy and greatly reduced test time. These tools have been applied to the investigations described in this report. Indeed, without these new equipments and test procedures, the data for this report would have required years to assemble because of the combinations of tests required and the time needed to plot isolation curves by hand.

1.4 PURPOSE

1.4.1 The purpose in writing this report is to focus attention on the performance limiting characteristics of FDM baseband cable plants currently used throughout the DCS and provide documented evidence that these limitations can be significantly reduced or totally eliminated through the application of FDM baseband cable plant technology.

1.4.2 Other important considerations are to:

1.4.2.1 Make available to all interested activities a single document presenting an accumulation of findings from both field and laboratory testing that constitutes the latest information collected on FDM-radio interfaces.

1.4.2.2 Make clear the reasons for and causes of a multiplicity of inconsistent and previously unexplained phenomena associated with baseband cable installations.

1.4.2.3 Provide a new approach to assessment of wideband facility RFI studies in terms of baseband cable plant isolation.

1.4.2.4 Justify changes to present baseband cable plant installation requirements such as:

1.4.2.4.1 Elimination of baseband cable appearances at the facility wideband patch bays.

1.4.2.4.2 Elimination of alternate (spare) baseband cables.

2.0 EVALUATION TECHNIQUES

2.1 Old Methods. Methods used by AFCS personnel during early investigations of baseband cable plants are described in detail in Appendix A. In brief, a +10 dBm signal was inserted into the radio end of the receive cable and the power induced into the transmit cable was measured at the radio end. Both cables were terminated in the combining panel by 75 ohm loads. A frequency selective voltmeter such as the Sierra 128A read the power directly in dBm to which was added 10 dB to obtain the absolute isolation between receive and transmit cables for a 3kHz slot. This data was plotted versus frequency on a graph to obtain a display of cable plant isolation throughout the baseband. Although crude and time consuming, this method provided a tool with which to assess isolation and thereby predict the performance of the cable plant in an operational configuration. First, the alternate cable plant would be inspected for installation defects and tested to determine their presence or absence. When the alternate cable plant was found to have an isolation of 85 dB or higher across the baseband, the cable plant was judged adequate. Traffic was switched to the alternate cables after baseline data consisting of idle channel noise, crosstalk, and test tone level was taken on the primary cable plant. Immediately on cutover to the alternate cables, baseline data would be taken to insure that link

performance was not degraded and evaluate noise and crosstalk improvements. Isolation tests would then be made on the primary cables and problems cleared. When the required isolation was obtained, traffic would be cut back to the primary cables and new baseline data taken. To appreciate the full scope of effort involved in this method, consider a 300 channel system from Hillingdon, U.K. to Martlesham Heath and consider three measurements per channel at both locations each time a cable was removed and returned to traffic. Using this method, it required from 3 days to a week at each location to correct a baseband cable plant. Often this effort was disrupted and data made invalid by necessary maintenance actions and equipment malfunctions occurring at sites between the facilities under test. However, despite the drawbacks to this method, it resulted in excellent system performance at a time when no other techniques were available.

2.2 New Methods.

2.2.1 The next major breakthrough in baseband cable plant analysis came in the fall of 1975 when Mr. Wilhelm Stoekle, electronic technician, and Mr. Fritz Liebrich, electrical engineer, both members of European Comm Area's 1945 Comm Group, were directed to investigate baseband cable plants at various USAF sites in Germany. Mr. Stoekle's prior experience in cable plant troubleshooting gained with the AFCS Scope Comm Office coupled with Mr. Liebrich's expertise in applications of the HP 141T frequency spectrum analyzer resulted in a new evaluation capability. Using baseband amplifiers (available in various configurations depending on the radios used) for amplification and decoupling, the residual signals in the transmit(XMIT) baseband cable could be displayed and graphed automatically by an X-Y recorder. The information obtained clearly showed the presence of any RFI, crosstalk, and ground loop noise existing in the baseband cable plant exclusive of traffic which was removed by pulling the supergroup looping plugs at the combining panel. A ten second sweep with a bandwidth of 3 kHz provided a distinct, unique, signature of the baseband cable plant's noise contribution. The approach here was to run an initial frequency signature of the transmit spectrum as installed and look for excessive RFI or noise across the baseband. If there appeared to be excessive noise present, inspection of the cable plant was made to insure that all grounds were intact and connectors properly installed. When the plant was deemed technically correct, a new signature was run to verify that the noise had been cleared or satisfactorily reduced. The use of this technique was demonstrated to the author in July 1977 at RAF Croughton, U.K. by Messrs. Liebrich and Stoekle during investigation of Task 44 England baseband cable installation problems at that location. The power of this new technique was readily apparent as was its shortcoming. While it was possible to rapidly test, correct, and retest cable plants, there was no companion method to display cable plant isolation, a key performance indicator. Only through characterization of the baseband cable plant's isolation under varying conditions and lengths could a basic understanding of their performance be developed and a baseline for their evaluation established. In short, it remained for baseband cable evaluation to be converted from an art based on emperical experience to an applied engineering science.

2.2.2 Working from previous developments, what could well be the final technique in baseband cable evaluation was implemented at the Richards-Gebaur AFB Prototype Test Facility (PTF) in September

1977. This was the addition of a HP 8443A Tracking Generator to the HP 141T Spectrum Analyzer. Applying a signal to the receive (REC) baseband cable from the tracking generator, the power induced into the transmit cable is measured and displayed on the 141T and plotted by an X-Y recorder. This provides a continuous isolation plot throughout the baseband spectrum which can be compared with the baseband frequency signature. The effect of isolation changes on baseband cable performance in terms of RFI and noise is readily apparent. Using isolation and frequency plotting, it is possible to completely characterize the performance of a baseband cable plant and establish performance standards.

2.3 DATA PRODUCTS. Data products resulting from the new baseband cable test methods take three forms: the frequency signature, the isolation characteristic and the composite frequency signature and isolation characteristic.

2.3.1 The Frequency Signature (See Fig 200.1). The frequency signature is displayed on graph paper 8 x 10 inches. Frequency is read horizontally from 100 kHz to 2,000 kHz (Supergroups 1 thru 8); signal amplitude is read vertically in -dBmØ. To convert the value read in dBmØ to dBm, add -45 dBm (XMIT TLP). Levels displayed are measured with a 3 kHz slot filter and 10 second sweep rate.

2.3.2 The Isolation Characteristic (See Fig 200.2). The isolation characteristic utilizes the same format as the frequency signature except for vertical levels which are read as absolute values of isolation in dB. Subtraction of 10 dB from the value read provides the level of the signal induced in the XMIT cable when treated as NEGATIVE dBm. Values of isolation read correctly to 120 dB however, limiting in the test set up results in nonlinearity for larger values. For example: a value of 127 dB read from the graph is actually 130 dB; 130 dB as read from the graph is 140 dB. A test calibration graph is shown in Fig 1.

2.3.3 Composite Display. Where amplitude and shape of the frequency signature and isolation characteristic permit dual presentation without confusion, a composite display of the signature and characteristic is shown on one graph. This simplifies their comparison and analysis. The sole change in format is that the upper portion of the graph is given in dBmØ while the lower portion is in dB.

2.4 TEST CONDITIONS.

2.4.1 TRIAX and COAX baseband cable plants in Fig 2 are shown in the NORMAL configuration. These configurations were found to provide maximum RFI, crosstalk, and ground loop noise reduction during previous field tests and were, therefore, adopted for use at many Air Force wideband facilities in West Germany and the United Kingdom.

2.4.1.1 NORMAL grounding for a TRIAX cable plant begins with a BNC connector at the radio end. The center conductor of the TRIAX is soldered inside of the BNC center pin and the inner and outer TRIAX shields are gathered together and clamped together within the BNC connector. At the multiplex

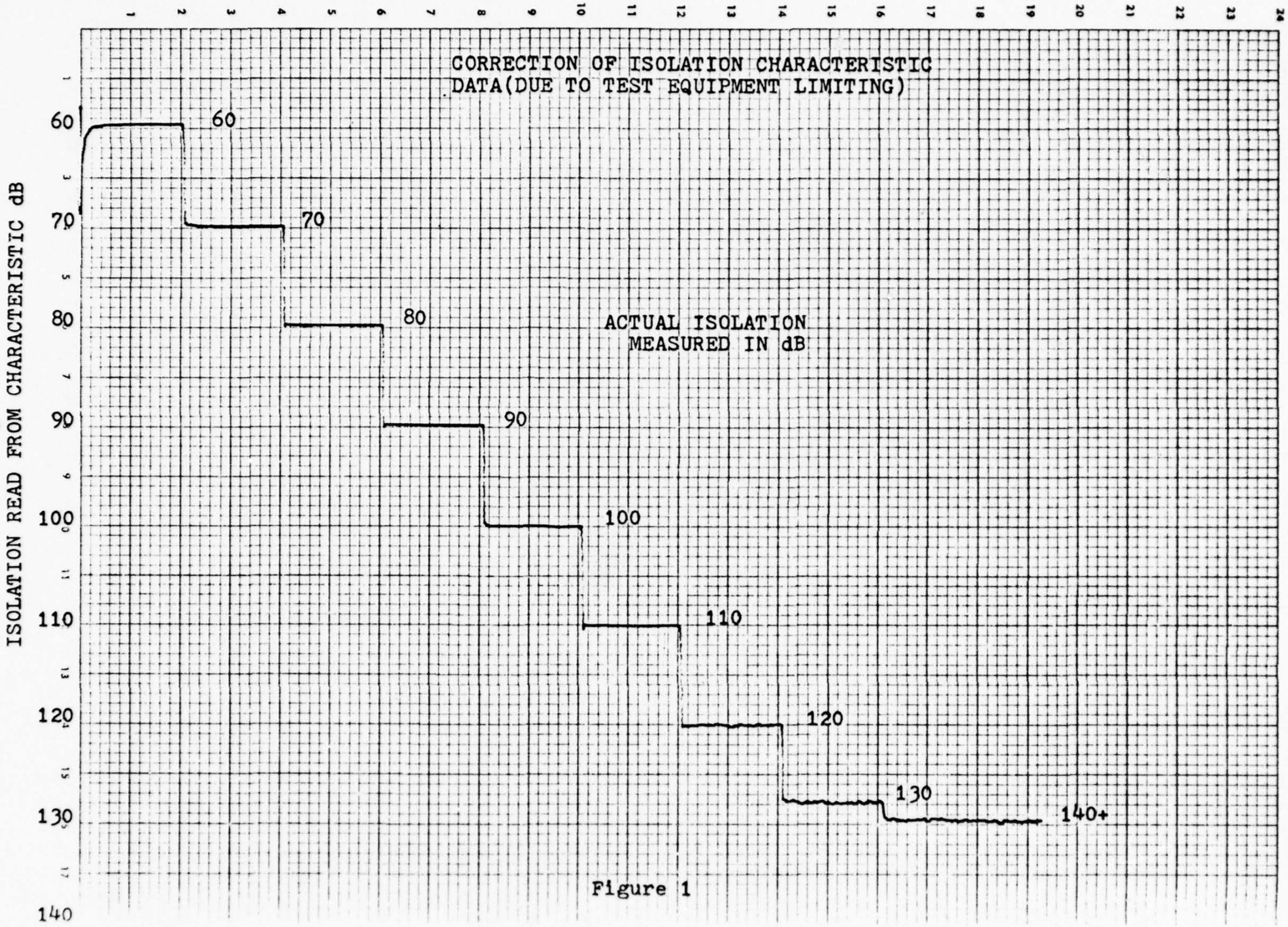
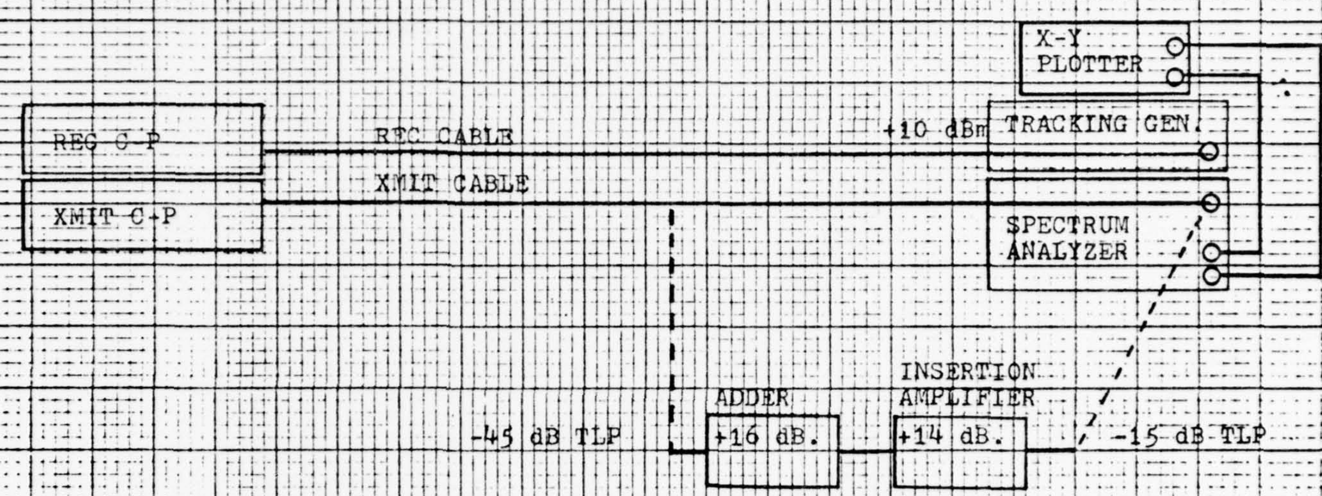

CORRECTION OF ISOLATION CHARACTERISTIC
DATA(DUE TO TEST EQUIPMENT LIMITING)
ACTUAL ISOLATION
MEASURED IN dB
ISOLATION READ FROM CHARACTERISTIC dB
60
70
80
90
100
110
120
130
140+
140

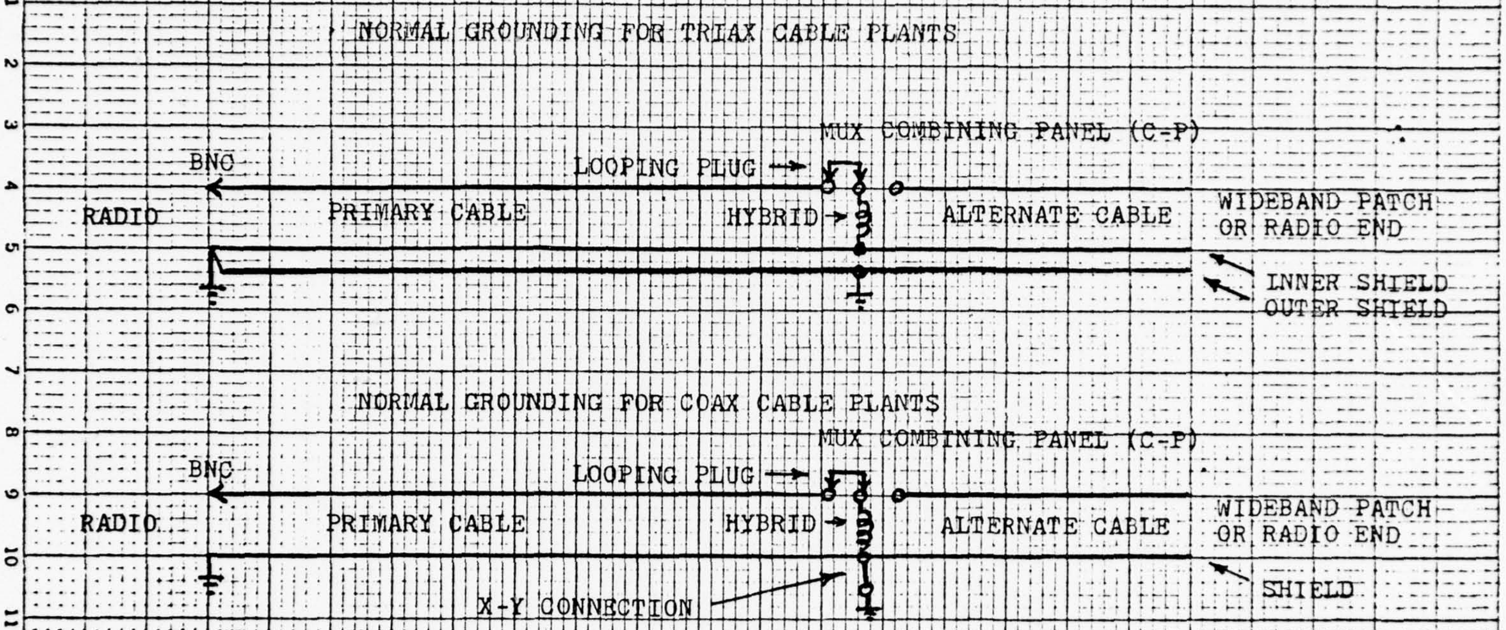
Figure 1

TEST EQUIPMENT SET UP FOR FREQUENCY SIGNATURE
AND ISOLATION CHARACTERISTIC MEASUREMENTS



NOTES:
1. Isolation is measured with cables in configuration shown as black solid lines above.
2. Frequency signature is taken by removing XMIT cable connector from spectrum analyzer input, connecting it to adder input and applying output of the insertion amplifier to spectrum analyzer input. Tracking generator output is turned off for this measurement. REC cable connector is left connected to tracking generator for proper grounding.
3. Test equipment is placed adjacent to radio and radio ground system is used for test equipment.
4. Adder and insertion amplifier levels were strapped to provide gain shown.
5. Alternate cables are not shown.

Figure 3



NOTE: Above shielding configurations are currently used extensively as standards for TRIAX and COAX baseband cable plants and are therefore identified as NORMAL GROUNDING for the purposes of this report.

Figure 2

combining panel the TRIAX center conductor terminates in a WECO jack and is connected to the multiplex HYBRID input or output transformer by a looping plug. The inner shield of both the alternate and primary cable share a mutual, isolated ground with the HYBRID. The outer shields of the primary and alternate TRIAX cables are connected to station (equipment) ground within the combining panel cabinet. The alternate cable center conductor terminates on a WECO jack and may be placed in service by removing the looping plug from the primary-HYBRID jacks and inserting it in the HYBRID-alternate jacks. Cabling is installed the same for both XMIT and REC cables. Special note should be taken that the HYBRID and TRIAX inner shields are NOT connected to cabinet ground in the NORMAL TRIAX configuration.

2.4.1.2 NORMAL grounding for a COAX cable plant differs from that of a TRIAX plant because only one braid (shield) is available. The single braid must serve as both a shield and a signal return path. Double braid COAX presents the same problem. At the radio end, the COAX cable terminates in a BNC connector. At the multiplex combining panel, the COAX center conductor terminates on a WECO jack. The looping plug provides connection of the cable center conductor to the HYBRID. The shields of the primary and alternate cables are connected to the common, isolated, HYBRID ground which is strapped to cabinet ground. This strapping is called X-Y strapping. The use of X-Y strapping with COAX is required to reduce RFI.

2.4.1.3 During recent tests, many variations from NORMAL grounding have been made to explore their effect on TRIAX and COAX cable plants. The results of these tests are discussed later in this report.

2.5 TEST EQUIPMENT AND PROCEDURES.

2.5.1 A block diagram of the standard test set up used to obtain frequency signatures and isolation characteristics is provided in Fig 3. The test equipment used consists of:

a. H.P. 7035B X-Y Recorder

b. H.P. 8443A Tracking Generator

c. H.P. 141T Mainframe equipped with: H.P. 8553B R.F. Section and H.P. 8552B I.F. Section.

In addition, use is made of the LC-8 radio adder and insertion amplifier to expand the range of the H.P. 141T. The new DCA standard radio series has a baseband amplifier which can be utilized for the same application. The value of using the as-installed radio components vice external amplifiers is that all basic components of the baseband cable plant are tested as a system. Excess noise in the amplifier modules can be checked for by terminating their inputs with 75 ohm terminations and sweeping the amplifier output.

2.5.2 XMIT and REC baseband cables were spaced close together for all tests reported herein unless

otherwise indicated on the signature and characteristic. Primary cable lengths of 200 ft or greater were laid out in rectangular loop configuration on the test building roof. Care was required to insure that cables were dry unless damp test conditions were required. Primary and alternate cable lengths of 100 ft or less were dressed about the interior of the test facility.

2.5.3 To obtain an isolation characteristic, test equipment and baseband cables are connected as shown in Fig 3. The tracking generator is set to sweep from 100 kHz to 2,000 kHz with 1 kHz resolution. The output is set for +10 dBm into the REC cable at the radio end. The radio end of the XMIT cable is connected to the 141T input. The R.F. section of the 141T is set for a 3 kHz bandwidth and a 0.2 MHz SCAN WIDTH PER DIVISION. The I.F. section is set up for: SCAN TIME 10 sec., LOG REF LEVEL -50, SINGLE SCAN, VIDEO FILTER OFF. The X-Y recorder "Y" input is connected to the 141T vertical output; the "X" input is connected to the 141T SCAN OUT terminal. To obtain a frequency signature, use the same test set up with the exception that the XMIT cable terminates on the adder module input, the output of the adder module is applied to the input of the insertion amplifier and the output of the insertion amplifier is connected to the 141T input. The output of the tracking generator is set to maximum attenuation (120 dB) and the REC cable left in place on the generator's input connection.

2.6 SIGNATURE AND CHARACTERISTIC ANALYSIS.

2.6.1 A frequency signature for a 75 ft primary cable (with 50 ft alt cable) is shown in Fig 75.1. The -35 dBmØ reference level corresponds to a -50 dBm level measured at a -15 dB TLP (Note: dBm = dBmØ + TLP). Looking at the signature, six distinct RFI blips are shown located at 610, 710, 810, 980, 1190, and 1380 kHz. Three of these are significant: 810 kHz at -68.5 dBmØ, 980 kHz at -59 dBmØ, and 1380 kHz at -69 dBmØ. The 980 kHz signal level does not meet the -60 dBmØ single tone interference specification cited in MIL-STD-188C. The noise floor of the cable plant is -77 dBmØ or better. No ground loop noise is seen in this signature.

2.6.2 An isolation characteristic of the same 75 ft primary cable is also shown in Fig 75.1. The 110 dB reference level shown corresponds to a -100 dBm signal induced into the XMIT cable by the +10 dBm signal level in the REC cable. The isolation shown at 1250 kHz is read on the characteristic as 130 dB. This corresponds to an absolute isolation of 140 dB (see para 2.3.2) which is the upper limit for this test method. Isolations greater than 180 dB are found to exist at certain frequencies in TRIAX cable plants and can be calculated at specific frequencies through signature and characteristic RFI comparison for known lower values of isolation. For baseband cable plant evaluation, an upper limit of 140 dB suffices. In Fig 75.1 the characteristic isolation antinode is clearly displayed centered around 980 kHz. This antinode is a breakdown in isolation between the XMIT and REC cable plants. In this case, the minimum isolation is seen to be 117 dB which is more than enough to prevent cable crosstalk.

3.0 APPLICATION.

3.1 Baseband Cable Plant Noise Evaluation. The tools for baseband cable plant noise evaluation are the frequency signature and the isolation characteristic. They are quickly obtained once the test equipment has been set up and calibrated. Less than three minutes of down time is required to take this data when the testing is performed by experienced personnel. Evaluation of the data is then required.

3.1.1 The reason for making a frequency signature is that this datum provides a documented, visual display of the noise existing in the baseband cable plant under test. The noise seen in the signature will be transmitted to the distant station and is the noise floor for this particular cable plant configuration. Under operational conditions, this noise floor will combine with multiplex, radio, and waveguide noise contributions and be added to the baseband traffic. RFI and ground loop noise is displayed in terms of level and frequency. That portion of the baseband spectrum used for link traffic can be closely examined for the baseband cable plant's contribution to noise at the distant end. Should excessive RFI levels or ground loop noise be found in the signature, corrective action must be taken on the baseband cable plant as only baseband cable plant noise contributions are shown in the signature.

3.1.2 The isolation characteristic provides the value of absolute isolation between the XMIT and REC portions of the baseband cable plant throughout the desired frequency spectrum. This information is vital to an accurate assessment of a plant's performance. Usually a multiplex is found to be operating under partially loaded conditions and, therefore, crosstalk may not be seen in the signature yet become a problem under full loading. Examination of the isolation characteristic will show what the absolute isolation is between cable plants over the frequency range utilized by the link traffic. For a single link, a minimum of 85 dB* is required to prevent crosstalk from the REC to the XMIT portion of the cable plant. This level of isolation will not be sufficient if the facility is located in an area of high RFI sources. Here again, correction of the cable plant may be required to optimize its isolation over portions of the baseband where RFI disturbs mission traffic. The isolation characteristic will reveal the location of isolation antinodes and provide firm data on which corrective actions can be based.

* Isolation requirements are discussed in para 2.4 of reference 1.2.1.

3.2 Baseband Cable Plant Comparison. Comparative evaluations of baseband cable plants in the past have required excessive amounts of time to accomplish. During such testing, variations in system loading and maintenance actions have frequently invalidated much of the data acquired. To obtain accurate data, constant involvement of highly experienced personnel was required to spot inconsistent test results. The frequency signature and isolation characteristic provide two powerful new tools for cable plant analysis and make possible evaluations in minimum time using less experienced personnel. TRIAX, COAX, TWINAX (balanced), and Fiber Optic plants for FDM-radio interfaces can be

checked for relative and absolute performance in the laboratory or in operational facilities. Minimal test time is required; reliable data is recorded.

3.3 Facility Baseline Data for Baseband Cable Plants. Taking the signature and characteristic of a baseband cable plant is a logical step in the location and correction of wideband system noise problems. Testing for radio and multiplex equipment is standardized on a component basis. The radio must meet specifications when tested alone; the multiplex must meet specifications when tested alone. When these two equipments are connected together by the baseband cable plant (and thereby become a subsystem) their combined performance is often disappointing. Neither the performance of the radio or the multiplex has changed. The change has resulted from the noise contributions of the baseband cable plant. Because of this, the baseband cable plant must be treated as a distinct subsystem component. It must be made to meet specifications that will complement the radio and multiplex performance; it must be characterized in terms of its signature and characteristic; and it must be tested again at periodic intervals to insure that variations from this baseline data do not go unaccounted for. A stabilized baseband cable plant (a plant unaffected by physical or environmental changes) will have a signature and characteristic that remain constant with time. Defective connectors, changes to the cable plant's grounding configuration and new sources of RFI will be easily detected by comparison of new signatures and characteristics with the original baseline data. Characterization of the baseband cable plant for baseline data will make possible a systematic technique for troubleshooting subsystem noise problems.

4.0 BASEBAND CABLE PLANT DATA ANALYSIS. The tests performed during the preparation of this report use the NORMAL (Ref para 2.4.1) grounding configuration as a baseline for comparison. Changes to the NORMAL configuration (removal of shield grounds, etc.) are followed with new signatures and characteristics to show the effects on the cable plant tested. The same procedure is used for both TRIAX and COAX baseband interfaces.

4.1 TRIAX Cable Plant Tests. Appendix B contains sets of data for TRIAX baseband cable lengths of: 25, 50, 75, 100, 200, 300, 400, and 500 feet. Study of this data provides information vital to the design and installation of low noise baseband cable plants.

4.1.1 Isolation Antinodes. (See Figs 25.1, 50.1, 75.1, 100.1, 200.1 and 200.2, 300.1 and 300.2, 400.1 and 400.2, and 500.1) The isolation antinode is a breakdown in cable plant isolation caused by resonance of the inner and outer TRIAX cable shields. Antinodes exist within the baseband frequency spectrum of each cable plant tested. The frequencies at which they occur is a function of the combined length of the primary and alternate cables. For cable plants less than 100 feet, only the fundamental antinodes affect the cable isolation. Third and fifth harmonics of the fundamental antinode are above the baseband frequency spectrum. For cable lengths of 100 feet or longer, a second and then third antinode appear with increasing length. Cable plants of 200 feet or longer (with 50 foot alternate cables) suffer isolation degradation of 24 to 35 dB over portions of the baseband spectrum while cable plants of 100 feet or shorter are seen to lose 13 dB or less. The worst case

degradation due to antinodes is shown in Fig 300.2 where the second antinode (third harmonic) reduces the cable pair isolation to 94.5 dB. While this value of isolation is adequate to prevent cable crosstalk, it falls far short of the isolation needed to effectively combat radio frequency interference.

4.1.1.1 Radio Frequency Interference and Antinodes. It is no accident that RFI and the antinodes are seen to affect the same portions of the frequency spectrum. Looking at the signature of Fig 25.1, a broadcast station is seen at 1380 KHz at a level of -49 dBmØ and the antinode isolation is 121 dB. The measured field intensity of the broadcast station is 73 dBuV/m. At 610 kHz, a station is seen at a level of -74 dBmØ. The measured field intensity of this second station is 84 dBuV/m. The RFI seen in the frequency signature is limited by the isolation of the transmit cable. The single cable isolation is roughly (within 6 dB) equal to one half of the pair isolation or, at 1380 kHz, 60.5 dB. By comparing levels and field intensities, the single cable isolation of the baseband cables at 610 kHz can be estimated at 96.5 dB based on actual performance. Or, the pair isolation at 610 kHz is approximately 193 dB. It can be seen by this example that a radical difference in cable plant isolation takes place in that portion of the baseband spectrum affected by the isolation antinodes. Removal of isolation antinodes from the baseband spectrum is needed to reduce or eliminate RFI in the baseband cable plant. When this is not possible because of excessive cable lengths, isolation antinode shifting techniques may be utilized to move the antinode to a portion of the baseband where it does not affect mission traffic.

4.1.1.2 Shifting Isolation Antinodes. There are a variety of techniques that can be employed to shift the antinodes.

4.1.1.2.1 Alternate Cable Removal. Fig 25.8 shows the effects of removal of the 50 foot alternate cables from the multiplex combining panels. Based on the data provided in para 4.1.1.1, the per cable isolation at 1380 kHz has increased to 87.5 dB. The actual paired isolation is in the vicinity of 175 dB. The fundamental antinode has been shifted to the 5 megacycle region leaving behind a smooth isolation characteristic. All RFI has been reduced to -73 dBmØ or lower. Antinode shifting has produced an ideal baseband interface with a noise contribution well below the multiplex idle channel noise specified for any 3 kHz slot throughout the baseband. A similar improvement in the performance of a 50 foot baseband cable plant is shown in Fig 50.8 where again the alternate 50 foot baseband cables have been removed from the combining panel. The RFI spike located at 1380 kHz in Fig 50.1 is reduced by 5 dB resulting in a single tone interference level of -66 dBmØ from one broadcast station while all other RFI levels are reduced to -73 dBmØ or less. Figs 75.1, 75.8, 75.9, 100.1 and 100.14 show the improvements obtained by alternate cable removal from 75 and 100 feet cable plants.

4.1.1.2.2 Coaxial Shorting. A second shifting technique that is easily employed where needed is coaxial shorting of the alternate baseband cable. This is accomplished by shorting the inner and outer shield braids of each of the alternate cables together at the wideband patch (or radio end) of the cables. The symmetry of the braids should be maintained and clamped together or soldered. A BNC

connector can be used for this purpose provided its shell is not grounded. Grounding of the alternate cable shields will result in a severe loss of cable plant isolation and cause increased levels of RFI to appear in the transmit cable. Application of coaxial shorts to the alternate cables will cause the frequency at which the isolation antinode appears in the baseband spectrum to double. Also, the 2nd and 3rd antinodes appear at the 2nd and 3rd harmonics of the first antinode. Looking at figure 100.1 and 100.16 the antinode is seen to shift from 840 kHz to 1710 kHz as read from the graphs. While this technique can be very effective, it must be used only in conjunction with testing that provides frequency signatures and isolation characteristics to insure that no ground loop noise has developed in the traffic carrying portion of the baseband spectrum. Shorting of the inner and outer shields together provides a low frequency - direct current X-Y connection at the combining panel. This will permit ground loop currents to flow on the inner shield of the TRIAX cable between radio and multiplex grounds. Should a significant difference in ground potential exist, the noise generated can be quickly identified in the signature and an alternative method of shifting used to obtain the desired improvement.

4.1.1.2.3 Extended Alternates. Extend the length of the alternate cables where the length of the primary cables and existing alternate cables result in an isolation antinode falling into a traffic portion of the baseband. This technique is seen in Figs 200.20 and 200.25 where by switching from 50 to 75 foot alternate cables the antinode shifts downward in frequency from 570 kHz to 510 kHz. The result is a 6 dB improvement in noise performance at 600 kHz. Figs 500.58 and 500.59 show 35 foot alternate cables installed for use as coaxial shorts. The results are that all RFI is reduced to less than -70 dBmØ throughout the baseband. This is remarkable performance for a 500 foot cable plant. However, that such performance is possible should not be considered as an indorsement for long cable plants. The ability of the equipment utilized to overcome cable plant losses must be considered; environmental and physical protection can be limiting factors.

4.1.2 *Variations from NORMAL Grounding.* *Variations from* NORMAL grounding in TRIAX cable plants should be considered as plant defects unless they result from utilization of the techniques described above for antinode shifting. Tests performed on TRIAX cable plants have shown that variation from the NORMAL configuration results in loss of cable plant isolation and generally significantly higher levels of RFI and noise. The effects of variations on a 25 foot cable plant are shown in Figs 25.2 thru 25.17.

4.1.2.1 Removal of Cable Shields from Ground at Combining Panel (C-P). The most common cause of RFI and ground loop noise encountered in TRIAX cable plants is failure of the installer to ground the outer shields of the REC and XMIT cables (primary and alternate) to the equipment grounds within the combining panels. The results are clearly shown as follows:

4.1.2.1.1 Isolation Losses. Fig 25.2 shows the isolation losses between the XMIT and REC cable plants for: XMIT shield ungrounded in C-P; REC shield ungrounded in C-P; and XMIT and REC (simultaneously) ungrounded in C-P. In each case, major losses in isolation are seen when compared

with the NORMAL (shields grounded in C-P) configuration.

4.1.2.1.2 RFI Increase. Figs 25.3, 25.4, and 25.5 show the frequency signatures for the three conditions described above. While loss of the shield ground from the REC cable has had slight effect on the signature (when compared with the NORMAL signature) in the existing RFI environment, the loss in isolation will permit entrance of RFI into the REC cable in the presence of exceptionally strong broadcast stations.

4.1.2.1.3 Comparison of the data shown in Figs 25.9 thru 25.12 with the signature and characteristic of the 25 foot NORMAL configured plant (Fig 25.8) with alternate cables removed show the same effects discussed in paragraphs 4.1.2.1.1 and 4.1.2.1.2: variations from the NORMAL configuration result in isolation loss and increased susceptibility to RFI.

4.1.2.2 Special Shielding and Grounding Techniques.

4.1.2.2.1 Fig 25.13 shows the application of a special shielding technique suggested for baseband cables. On the receive cable, the outer TRIAX shield is ungrounded at the radio and grounded at the C-P; the transmit cable outer shield is ungrounded at the C-P and grounded at the radio. Fig 25.14 shows the reverse of this technique. This shielding technique was tested for a number of cable lengths with similar results. The data shows that this technique cannot be used for FDM-radio interfaces currently used in the DCS. Its applicability to other situations was not investigated.

4.1.2.2.2 Fig 200.37 shows another method of shielding and grounding the TRIAX cable plant. The 200 foot transmit and receive cables have had their outer shield cut into five segments each of which is grounded at one end. The results were disastrous in terms of isolation loss and increased RFI. Again, no comments can be made as to the usefulness of this technique in other applications; however, it is evident that it cannot be used for FDM baseband interfaces.

4.1.2.2.3 An often suggested method for reduction of RFI on TRIAX cable plants is to ground the outer shield frequently or every one tenth wavelength. This was tried for both 200 foot and 500 foot baseband cable plants. Figs 200.16 thru 200.20 show the effect of adding 1, 3, and then 5 additional grounds to the outer shields of a 200 foot cable plant which was otherwise NORMAL configured. Figs 500.20 thru 500.47 are a similar series showing the effects of grounding the outer shields of the XMIT and REC cables of a 500 foot plant at various points and in various combinations. What is seen from this data is that numerous grounds (much more frequent than every one tenth wavelength) are required to achieve a significant reduction in RFI and that random application of grounds may increase the incidence and level of RFI in the cable plant. It is clearly evident that attaching any grounds to the outer cable shield beyond those used for the NORMAL installation should be avoided at operational facilities unless trained test personnel and test equipment are present to determine their effect upon the cable plant. Generally, multiple grounding of the cable plants outer shields is impractical due to the physical placement of the cables within conduits, cable troughs, and within buildings.

Where the length of the grounding wires is equal to the length of the cable shield from connecting point to a normal ground point, little is accomplished by adding an extra ground. A final consideration here is that performance equal to or better than that obtained through multiple grounding is more easily obtained through the antinode shifting techniques discussed previously (see Figs 200.27 and 500.61).

4.1.2.4 Cable Dampness. Comparison of Figs 500.48 and 500.49 with Figs 500.42 and 500.43 and Figs 500.46 and 500.47 with 500.50 and 500.51 shows the effect of moisture on TRIAX cable plants. Isolation is seen to degrade and RFI to increase with cable dampness. These effects were seen to exist for both continuous jackets and broken jackets (jacket penetrations for connections of grounds to TRIAX outer shields).

4.1.2.5 Alternate Cable Shield Grounding. Grounding of the alternate cable shields has a pronounced effect on the performance of the primary cables. Figs 500.40, 500.41, 500.54, and 500.55 show increases in RFI and isolation losses which take place when the outer shields of the alternate XMIT and REC cables are grounded at the wideband patch. Fig 500.2 shows the effects on primary cable plant isolation for the following conditions: neither XMIT or REC outer shield is grounded in the combining panel; REC outer shield grounded and XMIT outer shield ungrounded in combining panel; and both REC and XMIT shields grounded in combining panel. The losses in isolation caused by the outer shields not being grounded are seen to be severe (8 to 35 dB).

4.1.2.6 X-Y Strapping. Numerous tests for X-Y strapping (connection of inner and outer shields of REC and XMIT cables to ground at C-P) were performed with uniform results. Typical examples are shown in the signature series 500.9 thru 500.11. X-Y strapping of TRIAX cable causes extreme loss of isolation with the usual attendant increase in RFI. Fig 500.15 shows the isolation loss (8 to 48 dB) of a 500 foot cable plant when the X-Y strapping is applied to both XMIT and REC cable shields in the C-P.

4.1.2.7 Primary Cable Shield Grounding at the Radio. A defect often found in TRIAX cable plants is a poor outer shield connection in the XMIT or REC cable BNC connectors at the radio end of the cable plant. The outer and inner shields must be securely clamped together by the BNC connector otherwise the cable plant will suffer acute reduction in isolation. Fig 500.16 depicts these lost outer shield (ungrounded) effects.

4.1.2.8 Combining Panel Hybrid. Fig 500.14 is important in that it shows the combining panel hybrid to function as principally a resistive load throughout the baseband spectrum. The combining panel hybrid is compared here with a 75 ohm load to determine if the hybrid introduces reactive influences on the cable plant isolation. The isolation characteristic is found to remain virtually the same with either hybrid or resistive terminations indicating that the hybrid provides an excellent match for the 75 ohm transmission lines used in TRIAX interfaces.

TABLE I

FIELD INTENSITY MEASUREMENTS AT RAF CROUGHTON, OPEN AREA

FREQUENCY (kHz)	FIELD INTENSITY - dBµV/m LOCATION # 1 0900 HRS (1)	1300 HRS (2)	1530 HRS (3)	REMARKS
18		99		
60	86	94	94	Pulse CW
72	92	92		TTY
110			74	MUX Signalling
130			76	
150		66	68	
163	80	80	82	
179		78	80	
200		100	102	
233		72	74	
247			61	
260			53	
379			42	Beacon
400			40	Beacon
443			56	CW Code
520			39	
555			41	
570	56	78	61	
585			38	
612			56	
647	108	108	107	
675			54	
692	71	74	69	
708			48	
748	56	55	56	
809	37-27			
881	63	61	63	
907	80	81	79	
925			43	
958	47		48	
980			39	
1005	54	55	54	
1030			44	
1052	75	76	75	
1090			45	
1116			45	
1151			50	
1214	78-58	74	73	
1335			41	
1360			47	
1459			50	
1484	62-59	82	61	
1530		64	40	
1546			45	
1561		77	57	
1580		73	53	

TABLE I (page 2)

FREQUENCY (kHz)	FIELD INTENSITY - dBμV/m LOCATION #1 0900 HRS (1)	1300 HRS (2)	1530 HRS (3)	REMARKS
2050		46		Faded Out
2330		32		Ireland
2500		45	33	Time Service
2600		37	37	Time Service
2850			39	
3180			37	
3200			41	
3290			61	

NOTES:

1. 11 July 1977, Weather warm, sunny.

2. 12 July 1977, Weather cool, partly cloudy.

3. 15 July 1977, Weather sunny - partly cloudy

4. Location #1 is 8 feet from inside fence corner east of radio room, bldg 32 (southeast of bldg 43).

TABLE II

FIELD INTENSITY MEASUREMENTS AT RAF UXBRIDGE, TWO OUTDOOR LOCATIONS

FREQUENCY (kHz)	FIELD INTENSITY - dBµV/m LOCATION #1	LOCATION #2	REMARKS
60	84	80	Pulsed Code
72	84	79	FSK
118	64	66	Signalling
132	78	74	FSK
150	67	62	Music
163	85	80	ORTF
179	81	77	Belgium
200	94	90	BBC-2
218	61		Radio
233	78	73	Radio
260	58	52	Radio
275	54	48	Beacon
311	48	43	Beacon
322	50	45	Beacon
350	44	39	Beacon
383	46	41	Beacon
479	55		Code
555	48	46	Music
570	53	48	Radio
585	44	36	Music
620	58	52	ORTF
647	94	89	BBC-4
675	65	60	Music
692	75	67	Drama
708	56	51	Speech
748	70	66	Music
809	80	76	Speech
881	56	51	Drama
907	106	101	Drama
925	52	49	Music
958	58	53	Speech
1005	58	56	ORTF
1030	54	52	BBC
1052	72	65	BBC
1080	53	52	Music
1151	88	85	LBC
1214	95	92	BBC-1
1370	53	44	Speech
1420	41		Music
1450	75	77	Speech
1480	53	42	Music
1546	86	79	Capitol Radio
1561	65	49	Speech
3300	46	43	Carrier

4.1.3 Baseband Sweeps and Loading Measurements. The practice of making baseband sweeps and loading measurements at the wideband patch bay results in high levels of RFI, ground loop noise, and crosstalk being injected into DCS circuits. Regardless of whether the meters used are balanced or unbalanced, they cause a radical loss in isolation when connected into the baseband cable plant at any point other than at the radio input and output. Fig 500.62 shows the signature and characteristic for a 500 foot NORMAL configured cable plant. Fig 500.63 depicts the signature and characteristic for the same cable plant with a BNC "T" connector inserted in the XMIT cable at the input to the radio adder module. A H.P. 312A FREQUENCY SELECTIVE VOLTMETER (FSV) set for unbalanced-bridged operation is connected into the "T". It is seen that the connection of the FSV for measurements at this point do not effect the performance of the cable plant. Figs 500.64 and 500.65 show the effects of making balanced and unbalanced measurements with the FSV at a simulated wideband patch appearance. Similar results were obtained when a 128A FSV was bridged into the baseband cable plant at Croughton, U.K. during earlier testing (see Fig 200.42).

4.2 <u>COAX Cable Plant Tests.</u> Appendix C contains data for COAX baseband cable plants with lengths: 25, 50, 75, and 100 feet. Also, data is provided on a 31 foot WECO double shielded COAX cable plant. The value of this data rests in that the frequency signature and isolation characteristic provide a graphic portrayal of COAX baseband cable plant performance. What is particularly striking about this data is that while the majority of baseband interfaces throughout the DCS are COAX, the best performance obtained is poor when compared with worst case NORMAL TRIAX installations.

4.2.1 <u>COAX Cable Plant Isolation.</u> Fig 25.19 shows the isolation characteristic for a 25 foot NORMAL connected COAX baseband cable plant. The pair isolation is seen to be less than 130 dB and the single cable isolation approximately 65 dB. RFI spikes are seen to breakthrough the isolation throughout the full baseband spectrum (within broadcast band). Figs 50.16, 75.17, and 100.23 verify even worse isolation performance for longer length cable plants. Looking at Fig 75.18, the COAX cable plant isolation deteriorates rapidly because the X-Y connections have been removed at the combining panels. Although this would not be NORMAL configuration for a COAX cable plant, it can occur as an installation error and go undetected if only supergroup one is utilized. In Europe, RFI spikes would be seen in the frequency range of 60 kHz and upward as this portion of the spectrum is used for broadcast purposes. Tables I and II have been extracted from reference 1.2.3 to show the RFI environment at RAF Croughton and RAF Uxbridge, England. Study of these tables show strong sources of RFI distributed throughout the full baseband spectrum (60 to 2540 kHz) at those locations.

4.2.2 <u>RFI in COAX Cable Plants.</u> Again looking at Figs 25.19, 50.16, 75.17, and 100.23, high levels of RFI are seen throughout the broadcast band portion of the signatures. Comparison of these COAX cable plant signatures with equivalent NORMAL TRIAX installations illustrates the exceptionally high performance of the TRIAX cable plants. Fig 25.19 shows 7 hits (RFI spikes -60 dBmØ or higher) on the 25 foot COAX plant; Fig 25.1 shows 1 hit on the NORMAL TRIAX plant; and Fig 25.8 shows no hits taking place on the antinode shifted NORMAL TRIAX plant and all spikes reduced to -74 dBmØ or less. Fig 100.23 shows 4 hits on a 100 foot COAX plant; Fig 100.1 shows no hits on a NORMAL TRIAX plant and all

spikes -61 or lower; Fig 100.14 shows no hits on one form of shifted antinode NORMAL TRIAX plant (maximum spike -65 dBmØ); and no hits on a second form of shifted antinode NORMAL TRIAX plant (maximum spike -71 dBmØ).

4.2.3 Double Shielded COAX. Fig 31.1 provides a signature and characteristic for a 31 foot NORMAL configured double shielded COAX cable plant. Its RFI performance is better than either the 25 or 50 foot COAX plants as only one hit is seen. While the pair isolation is less than that of the 25 foot plant, the isolation of the XMIT cable is several dB better than the REC cable isolation. The overall performance of the double shielded COAX plant does not measure up to that of the 25 foot NORMAL TRIAX plant except in the vicinity of the TRIAX plant antinode. With a shift of the antinode, as in Fig 25.8, the TRIAX plant is found to be significantly better in RFI rejection than the double shielded COAX plant.

4.3 Balanced Baseband Cable Plants. A valid question often asked of the author is, "Why don't we use balanced baseband cables?" The answer is equally valid; the radios and multiplex equipment are designed for unbalanced operation. To convert these equipments from unbalanced to balanced operation is a major task and there is no assurance at all that any improvement in performance beyond that currently obtainable with TRIAX cable would be realized. Field tests have been made on site fabricated and installed balanced cable plants. Their best performance has equalled that of NORMAL TRIAX installations for idle channel noise in loop back configurations; however, the low isolation (due to transformers utilized) the balanced plants exhibit make them vulnerable to crosstalk under actual loading conditions. The Siemens V60/V120 balanced baseband interface is often cited as an example of a high performance balanced cable plant. What is lost sight of here is that the transmit and receive levels of this equipment are set at +1.74 dBm. This choice of levels automatically provides a 30 dB advantage in crosstalk reduction and a 46.74 dB advantage over RFI induced into the cable plant. What is important here is to be aware that the performance of a TRIAX cable plant operating at the lower levels of -15 dBm receive and -45 dBm transmit equals or betters that of the Siemens interface regardless of its level advantages. Exhibit D contains historical information assembled on previous testing of balanced baseband cable plants and should be reviewed for a better appreciation of the time and effort that has been expended to date in the pursuit of a better performing balanced cable plant. The question is not whether a balanced cable plant capable of providing high performance can be designed, but rather: Why is it needed for FDM-radio interfaces when existing TRIAX cable plants are able to support this requirement?

5.0 BASEBAND CABLES AND SYSTEM NOISE. Modern FDM-radio systems such as those installed in Europe under the Scope Communications Program and the Augsburg Upgrade Program have provided the DCS with links capable of excellent and highly stable noise performance when NORMAL TRIAX baseband interfaces are utilized. Large variations in idle channel noise due to crosstalk from increased system loading are eliminated by the high isolation characteristics of the TRIAX cable plants. Fully quieted receivers result from high RSLs; the multiplex equipment is designed for low noise and long term stability. The outcome of this is that those facilities that have TRIAX cable plants installed in the

TABLE III

THIRTY DAY LINK IDLE CHANNEL NOISE DATA FOR COMPARISON OF NOISE PERFORMANCE ON SELECTED LINKS BEFORE AND AFTER TRIAX CABLE PLANTS WERE INSTALLED IN THE NORMAL CONFIGURATION

LANGERKOPF TO MUHL (GERMANY)

BEFORE			AFTER (NORMAL)	
FEB 1974	JUL 1974		FEB 1977	JUL 1977
64	66	(dBmØ) (3 kHz Flat)	69	70
61	65		69	69
64	65		68	69
66	64		68	70
65	65		68	69
66	66		68	70
66	66		69	70
64	67		69	69
67	65		69	68
68	67		69	68
68	64		68	69
67	65		69	70
68	65		70	70
68	65		70	69
67	66		65	69
64	67		70	69
63	67		69	69
61	68		69	70
68	68		69	70
68	67		69	70
68	67		69	69
64	69		69	69
66	67		68	69
63	68		69	69
67	68		69	70
68	69		69	69
67	68		69	69
67	69		69	70
67	69		68	70
68	66		68	69
65.8	66.6	(30 day average)	68.7	69.3

TABLE III (Page 2)

LANGERKOPF TO BANN (GERMANY)

(dBmØ)
(3 kHz Flat)

1975		1977 NORMAL
Jul.1		Jul.1
66		67
63		66
60		69
63		69
66		69
68		70
68		68
67		69
67		68
68		69
64		68
65		69
65		67
63		66
61		68
63		69
67		69
67		69
65		69
65		68
66		68
68		68
63		67
65		69
66		67
63		67
61		68
63		70
67		68
67		68
65	(30 day average)	68.2

NOTE: While the performance of these cable plants is seen to have increased by 3 dB, what is particularly significant is that the NORMAL configured base-band cable plants show stable day-to-day noise levels equivalent to the looped multiplex specification of -68.7 dBmØ.

NORMAL configuration are reporting exceptional idle channel noise performance through their Link Performance Assessment (LPA) data submissions. Thirty day averages for two of these links are shown in Table III. While these links demonstrate what is possible, they are in no way typical of a large percentage of DCS links. Noise in baseband cable plants is the primary limiting factor for many of these. Every FDM baseband cable plant appearance throughout the DCS provides a potential entry point for RFI. Every facility with a broadcast station in its vicinity has 10 kHz of its baseband spectrum subject to noise introduction. This noise is usually observed at the distant site rather than at the facility where it is introduced. Because of the broad coverage of most AM radio stations, efforts to identify the point of entrance of RFI into the system are frustrated. Often the receiving station is identified as the point of entrance because of the high levels of RFI from the broadcast station measured in the vicinity of the receiving site while the real culprit, the transmitting facility, goes undetected. With the new techniques for baseband cable plant evaluation described in this report, it is possible to systematically isolate and identify the entrance points of RFI into the DCS. Then, the cable plant, if TRIAX, can be NORMAL configured and antinode corrected, if required. COAX cable plants can be replaced with TRIAX where the output/input hybrids of the multiplex can be isolated from ground. In short, effective means are now available to minimize the effects of or completely eliminate RFI from the DCS and greatly reduce the idle channel noise distributed throughout its systems.

6. CHANNEL ECONOMICS. Although improvement in the performance of the DCS is usually sufficient to justify system noise reduction efforts, good engineering practices dictate that economics and conservation of resources must also be a consideration. A recent DCA study has placed a dollar and cents value on communication channels that indicates that improvement of baseband cable plants can be cost effective. Recognizing that the majority of wideband terminal facilities have one or more channels logged out due to RFI and many others degraded to the point where only selective utilization is possible, channel cost needs to be compared with the cost of returning lost channels to service. Channel cost averaged out for acquisition, installation, and maintenance per month per mile is cited as follows:

DCS COST PER CHANNEL

Minimum:	\$229 + \$1.39/mile
Maximum:	\$7.38/mile

LEASED COST PER CHANNEL

Minimum:	\$14.60/mile
Maximum:	\$835 + \$21.98/mile

Using these cost figures the channel costs between two DCS facilities range as follows:

Martlesham Heath, U.K. to Langerkopf, Germany
(522 miles)

DCS		
CHANNEL COST	Minimum:	$955
PER MONTH	Maximum:	$3850
LEASED		
CHANNEL COST	Minimum:	$7620
PER MONTH	Maximum:	$12,300

Croughton, U.K. to Uxbridge, U.K.
(46 miles)

DCS		
CHANNEL COST	Minimum:	$292
PER MONTH	Maximum:	$339
LEASED		
CHANNEL COST	Minimum:	$671
PER MONTH	Maximum:	$1846

These costs are averaged over active and spare channels; therefore, cost per channel increases proportionately for logged out channels. While the basics of these cost computations may not find universal agreement, it is readily apparent that a reasonable expenditure of funds per site ($800 to $3000) that results in returning one or more channels to service is supportable. A team composed of one electronic engineer and one electronic technician should be sufficient for the correction of those facilities where TRIAX cable plants are presently installed. For those facilities where COAX cable plants are to be replaced by TRIAX cable plants, two additional installation technicians will be required. Average time to correct a facility is estimated at three days.

7.0 SUMMARY. This report provides an in-depth discussion of the noise problems that are encountered in existing DCS FDM baseband cable plants. The causes of these problems are cited; test procedures to isolate and identify specific deficiencies are provided. Corrective techniques and their application for the reduction of noise within existing facilities are described. Often quoted (but unsuccessful in practice) methods for reducing RFI in TRIAX cable plants are discussed in terms of test results. System degrading measurement methods used to accomplish baseband sweeps and read baseband loading are disclosed. And finally, the economics of recovery of logged out communications channels is treated.

8.0 CONCLUSIONS.

8.1 Analysis of the baseband cable plant test data discussed in this report leads to the following conclusions:

8.1.1 Existing FDM baseband cable plants can be major entry ports to the DCS for RFI and noise because:

8.1.1.1 COAX baseband cable plants do not have sufficient isolation to effectively reduce RFI induced into their XMIT and REC cables.

8.1.1.2 COAX baseband cable plants are subject to high levels of crosstalk and ground loop noise.

8.1.1.3 TRIAX cable plants are not presently engineered to provide optimum performance.

8.1.1.4 Measurements made at the wideband patch monitor jacks for the XMIT and REC baseband cables are disruptive to the DCS: The NORMAL grounding configuration is altered causing high levels of RFI, crosstalk, and ground loop noise in the cables.

8.1.2 Use of NORMAL grounding and isolation antinode shifting techniques in TRIAX FDM baseband cable plants significantly reduces or eliminates RFI, ground loop noise, and crosstalk in the XMIT and REC cables.

8.1.3 Characterization of FDM baseband cable plants in terms of their frequency signature and isolation characteristic provide:

8.1.3.1 Immediate display of cable plant performance for evaluation and troubleshooting.

8.1.3.2 Baseline data for system noise assessment and isolation.

8.1.3.3 Baseline data for control and routine verification of cable plant integrity.

8.1.4 Baseband cable installation and test personnel require special training to insure that baseband cable plants are installed correctly and providing optimum performance.

9.0 RECOMMENDATIONS. The following recommendations are provided with the intention of improving the operational performance of the DCS wideband radio systems and placing many logged out due-to-RFI channels in service:

9.1 Identification of RFI Channels. It is recommended that each service identify those wideband facilities under its control that currently have one or more channels logged out because of RFI or

excessive circuit noise. The types of multiplex and radio equipment affected should be determined and priorities assigned for corrective action.

9.2 Training. Each service should train and dedicate a limited number of dedicated teams for baseband cable testing and correction.

9.3 Evaluation. Evaluation of each facility should proceed based on the priorities assigned. Frequency signatures and isolation characteristics are taken and required methods of correction identified.

9.4 Correction. Where only minor changes to the cable plants are required, the test team trained above (paragraph 9.2) can accomplish the task. More complex changes (COAX to TRIAX conversions) may require assistance from local maintenance personnel or E&I personnel.

9.5 Characterization. As a final step in correction of the baseband cable plants at each facility, the cable plants should be characterized in terms of their frequency signatures and isolation characteristics. This will establish a permanent baseline for the performance of each cable plant.

9.6 Performance Verification. The final step in this effort is performance verification. While the corrected cable plants should provide stable performance indefinitely, mechanical and environmental damage may occur without warning. Dampness in the cable plant may increase RFI and noise levels; loss of a shield from a connector can degrade performance. Therefore, a planned program for testing baseband cable plants at fixed intervals should be established.

9.7 Cable Plant Configuration Changes. Appearance of the primary and alternate baseband cables at the wideband patch bay results in isolation losses (and therefore degraded performance), transmission level losses, and lower system reliability. Removal of primary and alternate cables from the wideband patch bays will: reduce the lengths of baseband cables (by 100 feet or more at facilities such as Feldberg, Germany); eliminate six or more TRIAX connectors and looping plugs from each XMIT and REC cable plant; simplify cable installation and troubleshooting (only one BNC connector in each cable plant); reduce baseband frequency slope due to cable losses; and provide optimum RFI and noise rejection through increased isolation. As the alternate cable plant is not required, connections to the alternate cable terminals in the combining panel should be made only for the purpose of isolation antinode shifting and then only under carefully controlled test conditions. Therefore, it is recommended that baseband cable plants be routed directly from the multiplex combining panels to the companion radio and alternate cables be disconnected from the combining panels unless needed for antinode shifting.

9.8 Baseband Sweeps and Loading Measurements. Finally, it is recommended that baseband sweeps and loading measurements on TRIAX baseband cable plants be made at the input/output terminals of the radio using a "T" connector. While this will require changes in tech control procedures at most facilities, there is no alternative as measurements made at the wideband patch monitor jacks cause high levels of noise in the cable plant that is transmitted into the system.

TABLE IV

FIELD INTENSITY OF BROADCAST STATIONS
MEASURED IN THE VICINITY OF THE PROTOTYPE
TEST FACILITY AT RICHARDS-GEBAUR AFB MO.

Frequency (kHz)	Field Intensity *(dBuV/m.)
610	84.5
710	85
810	83
970	82
1190	71
1380	73
1510	66.5
1590	60

* dBuV/m. is read as decibels above one microvolt per meter.

NOTE: The above information has been extracted from AFCS 1839 E-I Group Report - FMEA-77-16 Radio Frequency Survey of the AM Radio Band at the Test Facility, Bldg 1700, Richards-Gebaur AFB MO.

APPENDIX A

A REPORT ON
SCOPE COMMUNICATIONS BASEBAND CABLE PLANTS
ENGINEERING INSTALLATION AND TESTING
5 SEPTEMBER 1975

(Revised 10 Nov 1977)

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PREPARED BY

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FORWARD

The cutover to traffic of the Scope Communications Program HILLINGDON NORTH portion of Task 21, England, in December 1973 generated a concerted engineering effort by AFCS/EPZ to establish methods of testing and correcting defective baseband cable plants. From the moment the system was cut to traffic, it was plagued with excessive noise, cross talk and RFI over large portions of the baseband spectrum. Efforts by the Government contractor to correct this situation yielded little improvement. The contractor was able to identify the basic problem with the system as poor isolation in the baseband cable plants. He contended that the baseband cables, Government Furnished Equipment material, lacked sufficient isolation to meet the requirement, that it was defective. The responsibility for refuting this claim then became a task for AFCS/EPZ as part of their AFLC contract support function. Concurrent with this was the immediate need to provide substitute baseband cable plants in order to meet operational requirements.

It was decided that the AFCS/EPZ effort would progress through three stages: First, determine why the contractor installed interfaces did not perform properly. Second, promptly re-engineer the contractor interfaces for interim use. And third, replace the re-engineered interfaces with environmentally protected, high performance baseband cable plants. This was an ambitious but necessary effort to undertake. Time was of the essence, engineering and technical support extremely limited, and baseband cable plant testing and evaluation techniques unknown. The 2130th Comm Group was called upon to assist AFCS/EPZ personnel in conducting baseband investigations at Hillingdon, England. This was the beginning of an Air Force team effort that has extended over many months filled with accomplishments, frustrations and finally, success. It is with this total effort fresh in mind that the following information, guidance and admonishments are presented to those persons faced with the task of design, installation, testing and trouble shooting of wideband radio/multiplex baseband cable plants.

Frank La Dieu
Electronic Engineer

PURPOSE

This document has been prepared for use by those engineers and technicians confronted with the task of interfacing multiplex equipment with radio equipment. That some form of cabling is required is evident to all but information as to what type of cable and how to go about installing it is sadly lacking. Further, no adequate test procedures are available to assess the necessary technical characteristics of baseband cable plants at the time of installation and later on a link/subsystem basis.

The information presented herein has been collected over a two year period. It represents the composite contributions of hundreds of AFCS technical personnel distributed throughout the United Kingdom, Belgium and Germany and was made possible through the support provided by DCA Europe. It is believed that a sincere effort on the part of the baseband cable plant designer/installer to understand and adhere to the principles provided below will result in cable plants capable of providing the high performance required in today's wideband microwave systems.

1. <u>THE BASEBAND CABLE PLANT</u>

1.1 The Baseband Cables

Baseband cables are used to interconnect the output/input jacks of our multiplex equipment to the input/output (transmit/receive) jacks of the wideband microwave radio. These cables may be routed directly from multiplex equipment to the radio or may be routed through a wideband patch bay for the purpose of adding flexibility in patching of complete basebands to alternate radios should the requirement ever exist. Both routings will be discussed at length later but it is well to emphasize at this point that simplicity in baseband cable routing can minimize the number of connectors required between equipments, and thereby, eliminate a common source of system outages.

The type of cable chosen for fabrication of the baseband cables is extremely important. Factors that must be considered in its selection are as follows:

a. Balanced or unbalanced cable. This decision is usually predetermined by the equipments to be interconnected. Both the Philco Ford LC-4/8 radio series and the Collin's AN/TRC-150 radios have been designed for use with unbalanced 75 ohm coaxil cable input/output terminated in BNC connectors. The AN/UCC-4 multiplex equipment is also designed for use with unbalanced 75 ohm cables which terminate in the multiplex combining panels on solder lugs. Where Siemens multiplex is required to be interfaced with LC-4/8 radios, Siemens has provided interface equipment to convert their equipments balanced baseband interface to an unbalanced 75 ohm

configuration. It is necessary to solder the baseband cable to terminal lugs provided on the matching transformers installed in the multiplex equipment.

b. Cable shielding. The cables interconnecting the radio and multiplex equipment must perform the following functions as a minimum requirement:

(1) Prevent ground loop currents from being introduced into the signal path.

(2) Provide adequate baseband frequency isolation between each other as well as isolation from other cables in their vicinity.

(3) Isolate the baseband cables from broadcast radio signals and other forms of airborne RFI.

(4) Deliver the baseband information between radio and multiplex with a minimum of loss and slope.

c. Installation. The cable selected for the baseband must be of a size and flexibility that permit ease of installation. Due to space considerations within the wideband patch bays, module jack sizes and cable bundling, it is required that the cable size be restricted to 1/4 inch diameter or less. Connectors must be readily available and in such variety for the cable selected that all termination needs can be met. The cable itself must be reasonably strong and crush resistant so that the performance of the cable is not overly dependent on handling and variations of lacing. Often it is necessary to pull the baseband cables along with other types of cables through long runs of conduit where exposure to the elements and protection from mechanical damage is essential.

Again, this requires that the baseband cables selected must be able to withstand a reasonable amount of punishment and still perform properly.

All of the foregoing is brought out to drive home the point that selection of baseband cable cannot be approached in a whimsical manner. If a thorough consideration of all the requirements that the baseband cables must meet does not go into the cable selection, the odds are that the baseband cable will become a performance limiting element making it impossible to meet link and system standards for noise and crosstalk.

1.2 The Scope Comm Baseband Cable

Logically the question should be asked, "What kind of cable is available to meet all of the needs discussed above?" The answer is that there may be a number of types of cable available to do the job with but the one type utilized and thoroughly tested throughout numerous Scope Comm facilities is the TROMPETER TRC-75 triax cable; FSN 6145 2551480. When properly installed, this cable will provide outstanding performance in all necessary areas.

Now that a cable capable of meeting our needs has been identified, another question should be put forward and that is, "If the TRC-75 cable is used for interconnecting the radio and multiplex, with the cable shields properly utilized (which will be explained later) and the connectors installed correctly, can we be sure of proper baseband cable operation?" Unfortunately, the answer is "No". We have not discussed the baseband interface yet and therein rests the next problem area.

1.3 The Baseband Interface

The baseband interface is that portion of the radio/multiplex input/output circuitry extending from the input/output jacks to the first stage of active signal processing in either of these equipments. On some equipments, jacks are replaced by terminal lugs. Four distinct forms of baseband interfaces are:

a. LC-4/8 Radio. The baseband interface for these radios consists of BNC jacks, a bandpass filter network and a resistive padding network providing certain level adjustments for baseband signal levels applied to the radio. None of these components have been found to effect baseband cable performance.

b. AN/TRC-150 Radio. Again, the normal input/output jacks for this radio are BNC. Like the LC series above, this radio is designed for a 75 ohm single ended grounded baseband cable plant. No internal adjustments have been found to affect baseband cable performance.

c. AN/UCC-4 Multiplex. The Baseband Combining Panel serves as the baseband cable interface for this multiplex equipment. The Combining panel provides for termination of two sets of baseband cables (primary and alternate) on solder lugs in the rear of the panel. On the front of this panel a looping plug is provided to facilitate rapid changeover from primary to alternate cables should the need arise. The looping plugs connect the baseband cables through a strapable pad to the output of a single ended-floating transformer. Provisions have been made in the form of an X-Y strapping option to permit operating this transformer

output/input as either single ended-floating or single ended-grounded. Failure to utilize this option properly has resulted in severe ground looping and crosstalk problems at several locations.

d. Siemens FU60/120 Multiplex. This equipment requires special interface components as follows:

(1) An attenuator pad to drop the baseband output of the Siemens multiplex from a -15 dbm transmit level to a -45 dbm level.

(2) A pair of transformers to impedance match the normal 150 ohm baseband output/input cabling to the 75 ohm triax cable used for interface with LC-4/8 radios. Siemens part number for each transformer is Rel 15 C 485.

1.4 The Baseband Cable Plant.

For the purpose of clarity during baseband discussions, it is important that we define the baseband cable plant as the baseband cable complete with its multiplex and radio interfaces. Discourse on testing methods, test data and trouble shooting can only be meaningful when we know exactly what portion or part of the baseband cable plant is being discussed therefore it has been necessary to break the cable plant into its specific components, the multiplex interface, the radio interface and the baseband cable. With nomenclature and definitions out of the way, we are ready to consider the fine points of the various types of baseband cable plants utilized in the Scope Comm system. Drawings are provided to illustrate concepts and are not intended to substitute for the

thorough study each individual baseband interface requires. Remember this, the majority of baseband cable plant problems investigated by this office have resolved down to the baseband interfaces not being wired or configured as thought. If the interfaces are correct and the baseband cable properly installed, the baseband cable plant will do its intended job indefinitely barring mechanical damage to it. With the equipments discussed herein, the baseband cable plants are simple and straight forward in concept. If the designer/installer has complied with the procedures set forth in this paper and proper performance is not obtained, the cable plant must be inspected carefully to determine and correct the installation flaw. It may be something simple in nature such as a defective connector or be something more difficult to locate such as an unintentional grounding of the outer cable shield while passing through a shelter bulkhead. These types of defects can be extremely time consuming and frustrating.

2. CABLE PLANT THEORY

2.1 TRIAX and COAX Cable

Under the section on baseband cables we discussed various factors that had to be considered when determining what type of baseband cable to utilize in the baseband cable plant. A clear understanding of why a TRIAX type cable performs better in certain cases than a COAX cable is needed by the designer/troubleshooter. A pair of diagrams, Fig 1a and 2a, are provided for this purpose. These two diagrams are of such importance that they should be committed to memory. They will be utilized repeatedly in making

assessments of baseband cable installation and the ability to envision them can save many hours of confusion during troubleshooting.

Looking a Fig. 1a we see a standard COAX type cable installed between a signal source (multiplex) and a load (radio). Providing the cable length is kept short, outside sources of RFI (broadcast interference, adjacent baseband cables, etc.) shunt to ground rapidly without developing a significant signal component Ex(Ix) across the load. This tends to be equally true for ground loop currents Igl when the gnerator and load are close together and share a common ground. The role that Ex and Igl play in the signal delivered to Rl rapidly increases as the length of the cable increases. A simplified circuit diagram showing the cumulative effect of Ix, Igl and Ibb is presented in Fig. 1b. There is no attempt made here to go into a rigorous circuit analysis. It is sufficient that the buildup of these extraneous currents be recognized so that steps can be taken to avoid or minimize them.

So what can be done to reduce the effect of ground loop currents when using coax cable? The answer is to be sure that the coax cable goes to ground at only one end. At the other end, the signal generating end, the output must float above ground. What has been achieved here is single-ended transformer coupling - which is just what the AN/UCC-4 multiplex and the LC-4 radio have been designed to utilize. Does this solve all of our problems? No. But it does give us the best possible baseband cable plant we can expect to install using COAX cable. The effect of Ex may still defeat us and no doubt will if we must use close spaced transmit/

receive cables operating at -15/-45 dbm levels. Right away we know that we need 30 db more of isolation than we would require for equal levels.

A solution someone might be quick to suggest here would be to operate the baseband cable plant equi-level. The major drawback to this is that the equipments we are discussing here are designed to operate at the -15/-45 dbm levels and to operate otherwise means we must complicate our baseband cable plant by adding amplifiers and pads (components which add system noise and decrease system reliability). Fortunately, we don't have to choose this course of action because we can obtain all the isolation required between our baseband cables (bundled tightly or otherwise) simply by using TRIAX cable.

What does the TRIAX cable have to offer us that the COAX doesn't? The answer is a second shield which can effectively shunt Ix currents to ground without introducing them into the signal flow path. Figure 2a shows how the outer shield protects the inner shield from outside Ex fields and in similar fashion prevents radiation from the inner shield. Using TRIAX cable, we are able to utilize the center conductor and inner shield for single-ended transformer coupling of the multiplex equipment to the radio and thereby eliminate any possibility of ground loops between these equipments. The second thing that TRIAX does is furnish that extra outer shield which provides that additional margin of cable isolation required when operating colocated transmit and receive cables operating at -15/-45 dbm levels. Note that in Fig. 2b only one

current source remains to drive the load. This represents an ideal baseband cable plant which is virtually attained through the use of properly installed baseband cables.

2.2 Cable Crosstalk and Isolation

At this point we will discuss the need for isolation between the transmit and receive baseband cables and develop some ideas on what constitutes acceptable values of isolation.

Crosstalk is defined by DCA as the phenomenon in which a signal transmitted on one circuit or channel of a transmission system is detectable in another circuit or channel. With baseband cable plants, we are concerned with crosstalk between the receive and transmit baseband cables. The input/output isolation requirements for the multiplex and radio baseband interfaces are determined by the manufacturer's design and provide sufficient isolation to meet DCA standards. Therefore, with the lone exception of the Siemen's V60 interface which will be discussed later, crosstalk in the baseband cable plant is primarily dependent upon the degree of isolation developed between the transmit and receive cables.

DCA standards require that intelligible crosstalk in a channel must be at least 55 dB below the desired signal. This means that if we run two equi-level cables together, they must have an isolation of at least 55 dB to meet this standard. When we colocate receive and transmit cables carrying power levels of -15 dBm and -45 dBm respectively, the signal carried by the receive cable is 30 dB higher than the signal carried by the transmit cable. We must now increase the isolation between these cables by an

additional 30 dB in order to insure that the signals induced into the transmit cable appears 55 dB down (-100 dBm) from the -45 dBm transmit signal. The isolation between cables should be at least 85 dB.

A baseband cable plant having an isolation of 85 dB would meet the DCA requirement for single tone crosstalk if we are concerned with a single link. Unfortunately, we usually must traverse several relay facilities before delivering our traffic to its end destination. The isolation of the baseband cable plants at each facility will become a factor in our final determination of isolation requirements.

At this point, let us consider what we have said about cable isolation and utilize figures 3 through 5 to insure that we have a clear understanding of what takes place in the baseband cable. Figure 3 depicts a view of a cross section of a transmit/receive pair of baseband TRIAX cables. The field about the inner shield of the receive cable (-15 dBm) is shown to be much more intense than the field about the inner shield of the transmit cable (-45 dBm). The effect of the grounded outer shield of the receive cable is to reduce the intensity of the radiated receive signal. The grounding of the transmit cable outer shield provides additional protection of the transmit signal by shunting most of the induced receive signals to ground and thereby reducing again the effect of the higher receive levels on the transmit center conductor and inner shield. Isolation obtainable with properly installed cables is in the order of 120 dB.

It is important here to develop the concept of individual cable isolation as this will make clear why it is necessary to insist on all baseband cable plants within a facility meeting proper isolation standards. If we say that the total isolation between two cables is 120 dB, then we may say that each cable is contributing 60 dB of this isolation. The cables should be physically and electrically identical with only slight manufacturing variations. If each cable is properly installed, each will contribute equal values of isolation. With the individual cable isolation concept as a tool, we can develop a means of estimating total baseband cable plant isolation requirements. For example, if we run two receive cables parallel with two transmit cables and each cable has an individual isolation of 60 dB, the overall effect of the two receive cables is to reduce their combined isolation by 3 dB, which is to say, that the new isolation existing between the pair of receive cables and each transmit cable is now 117 dB. Should one of the receive cables not be properly installed and exhibit a low level of isolation, say 30 dB, the combined isolation of this cable and either of the transmit cables will be 90 dB. Consideration of this phenomenon will make clear why it is so necessary to insure that each and every baseband cable in a facility, where colocated, is installed in a manner which provides adequate isolation. One poorly installed receive cable will pollute adjacent transmit cables which are totally disassociated with the portion of the system of which the defective cable is a part. This type of condition is extremely hard to detect and is usally attributed to bad station grounds. Again,

the prime difficulty in detecting the source of such a problem is that active, traffic carrying systems are involved. Downtime to carry on the required investigation, isolation and testing of the cable plants involved is hard to come by. That is why it is so necessary to properly install the baseband cable plant initially and control carefully any subsequent installations that can impact the existing baseband cable plant.

Looking at Fig. 4, we see a typical link configuration for radio and multiplex equipment baseband cable plant testing. At the near end we are injecting a signal into a multiplex channel and observing the effect on the same channels receive. At the distant end, we have terminated both the receive channel and transmit channel. On the near end, the -45 dBm level of the transmit cable is 30 dB lower than the receive -15 dBm level. Crosstalk from transmit to receive is unlikely as even a poor absolute isolation (-25 dB) between receive and transmit cables would lower the crosstalk in the receive to the required 55 dB down level. Therefore, any crosstalk measured at the near end will be taking place in the far end cable plant where the -15 dBm receive signal crosstalks into the -45 dBm transmit cable. The isolation between receive and transmit baseband cables must be at least 85 dB to insure that the -15 dBm signal is reduced to a -100 dBm in the transmit cable. A -100 dBm signal will be 55 dB down from the transmit -45 dBm signal. The actual isolation attainable between TRIAX baseband cables is in the order of 120 dB or better when properly installed. The overall isolation of the baseband cable plant then becomes dependent on the isolation

characteristics of the radio and multiplex interfaces.

2.3 Cable Plant Testing.

Figure 5 shows a typical isolation test method used extensively by ECA/EPZ personnel to determine the combined baseband cables and multiplex interface isolation versus frequency characteristics. A Hewlett Packard 654A Test Oscillator is used in conjunction with a Hewlett Packard 5245L Frequency Counter to provide an accurate source of high level signal (plus 10 dBm) to the baseband cable at the radio end of the transmit cable. The multiplex end is terminated in the multiplex transmit baseband combining panel. The crosstalk induced into the receive cable by the signal in the transmit cable is measured at the radio end with a Sierra 128A Selective Voltmeter. The far end of the receive cable is terminated in the multiplex receive combining panel. Signals are injected into the transmit cable ranging in frequency from .06 to 3.2 MHz at a plus 10 dBm level and crosstalk readings recorded in terms of absolute dB difference between values measured on the 128A and the level supplied to the transmit cable by the test oscillator. This data is valuable in assessing the performance of the baseband cable and multiplex interface as no better performance can be expected when the cables are terminated in the radio equipment.

The same test setup can be a useful troubleshooting tool as it permits one to assess the baseband cables (including wideband patch appearances) isolation independent of the multiplex combining panels. The isolation of properly installed TRIAX cable over the baseband frequency range is in excess of 120 dB for lengths of cable up to

300 ft. The receive and transmit cables can be terminated at the radio entrance appearance on the wideband patch bay and isolation across the baseband measured to insure that proper isolation has been maintained to that point. It has been found necessary to use variations of this test technique in measuring baseband cable plants on a section by section basis in order to locate the components or cable sections that were causing isolation losses.

2.4 Determining Plant Isolation Requirements

Figures 6 and 7 provide the baseband cable plant designer with a conceptual technique for establishing isolation criteria needed per facility on a system/sub-system. In Fig. 6 we see two terminals with an intermediate baseband repeator site (RELAY). Each of the terminals have baseband cable plants involving multiplex and radio equipments. The relay site may have a simple baseband cable plant utilizing attenuators to drop the incoming receive levels to the required transmit levels or the plant may consist of a complex network of bridges, filters, attenuators, amplifiers and associated cabling. In either case, we have shown the cable plant to exhibit an absolute value of isolation of 85 dB for the purpose of illustration. If both terminals also have cable plants with 85 dB isolation, we can use the isolation diagram shwon in Fig. 7 to determine what the maximum subsystem isolation between transmit and receive channels can be. The isolation of the relay and distant terminal is represented by a resistance or pad symbol identified as having an isolation of 85 dB in each case. A little intuition tells us that two equivalue pads in parallel will shunt twice as much power from

the -15 dBm receive cable to the -45 dBm transmit cable as a single pad. Twice as much power is the same as a 3 dB increase in power or conversely, a 3 dB decrease in isolation (resistance). Therefore, the absolute value of system/sub-system isolation seen from the near end will be only 82 dB rather than the required 85 dB. This means that a 10 down tone inserted in a transmit channel at the near end will result in crosstalk 52 dB down in the near end receive channel rather than the 55 dB down specified by DCA. From this we can see that with a three baseband cable plant system, 85 dB plant isolation is insufficient to meet our system requirements. We can calculate the value of isolation required at each cable plant from the following formulas:

a. $$\text{SYSTEM ISOLATION LOSS (dB)} = -10 \log \frac{1}{N - 1} \quad \text{for } N > 1$$

where N is the number of equal isolation baseband cable plants the channel traverses.

b. $$\text{SYSTEM ISOLATION (dB)} = \text{EQUI-PLANT ISOLATION (dB)} \quad 10 \log \frac{1}{N - 1} \quad \text{for } N > 1$$

c. $$\text{MINIMUM PLANT ISOLATION (dB)} = 85 - 10 \log \frac{1}{N - 1} \quad \text{for } N > 1$$

EXAMPLES: Given a sub-system consisting of two terminals and two intermediate baseband repeators, what is the system isolation loss as measured from the near end? What is the system isolation if each baseband cable plant exhibits 85 dB of isolation individually?

The system will exhibit a system isolation loss (SIL) equal to:

$$SIL = -10 \log \frac{1}{4 - 1}$$

$$= -10 \log \quad 1/3$$

$$= -(-4.77) \text{ dB} = 4.77 \text{ dB}$$

If each cable plant has been designed for a 85 dB isolation (CPI), the system isolation (SI) will be:

$$SI = 85 + 10 \log \frac{1}{4 - 1}$$

$$85 + (-4.77)$$

$$80.22 \text{ dB}$$

If it is desired to maintain a system isolation of 85 dB (single tone interference 55 dB down), what must be the minimum plant isolation (MPI) exhibited by each baseband cable plant in each of the four facilities?

$$MPI = 85 - 10 \log \frac{1}{4 - 1}$$

$$85 - (-4.77)$$

$$89.77 \text{ dB}$$

One last formula may be used to evaluate how well the baseband cable plants are performing on a sub-system when the actual average crosstalk over the baseband is known.

SIA (System Isolation Average) = XTA (Baseband X-Talk Average) dB + 30 dB

$$MPI = SIA - 10 \log \frac{1}{N - 1}$$

For the Scope Comm sub-system Hillingdon - Botley Hill - Navy London, the X-talk average (XTA) is 65 dB when measured from Hillingdon. What is the MPI that can exist at Botley Hill or Navy London?

$$MPI = SIA - 10 \log \frac{1}{3 - 1} = 65\ dB + 30\ dB - 10 \log 1/2$$

$$95 + 3$$

$$98\ dB$$

In the reverse direction, Navy London - Botley Hill - Hillingdon, the X-talk average is 61.6 dB when measured from Navy London. This indicates that the MPI for Botley Hill or Hillingdon must be 94.6 dB or better. From the above calculations, we know that Botley Hill cable plant must be 98 dB or better. Therefore, we can be sure that the isolation of the baseband cable plant at Hillingdon for this sub-system is 94.6 dB or better. As the MPI for a 3 baseband cable plant system is 88 dB, we can see that the MPI for Hillingdon is exceeded by 6.6 dB and at Navy London and Botley Hill by at least 10 dB. The additional isolation available at these three locations is worth while in that it will provide an additional crosstalk safety margin for high system loading.

2.5 Frequency Dependence of Crosstalk and Isolation

Thus far in our discussions on baseband cable plants we have neglected to point out what role frequency plays in isolation and crosstalk. Two graphs showing plots of absolute isolation versus frequency are provided as part of this work in order to illustrate these relationships. Graph I is a plot of the Hillingdon, England, baseband cable plant interfacing the AN/UCC-4 multiplex equipment with the AN/TRC-150 radio on the path to Bovingdon. The measurement test set up was as shown in Figure 5. Studying this graph, we observe two very important characteristics of cable plant isolation.

First, grounding or not grounding the outer shield of TRIAX cable pairs makes a major difference in the isolation attainable at any given frequency. In fact, how the outer shield is grounded spells the difference in whether a cable plant can provide sufficient isolation to meet the DCA crosstalk limit or not in certain portions of the baseband frequency spectrum. Double ended outer shield grounding must be used to obtain maximum isolation of the cable plant. This rule applies to baseband cable plants ranging from 25 to 500 ft interfaces.

Second, there is a periodic component in baseband cable plant isolation. This isolation characteristic has been used frequently by contractor personnel to overcome isolation (crosstalk) problems in portions of the baseband cable plants frequency spectrum. The isolation signature, with its peaks and valleys, can be shifted frequency wise to provide best isolation in a specific (used) portion of the baseband spectrum by grounding the outer shield at intermediate locations between interfaces. This by no means improves the isolation of the overall cable plant. Rather, it shifts the poor isolation area into some other part of the baseband frequency spectrum which may eventually be needed for over building the facility. This practice should not be condoned as it only masks a poorly engineered and installed baseband cable plant which, with a reasonable effort, could be corrected to provide the minimal isolation required across the entire baseband. The conditions that make such gimmic correction techniques necessary usually result in additional idle channel noise that varies independently

from isolation or crosstalk. Increased idle channel noise may be developed from the same ground loop conditions that preclude attainment of the minimum isolation required at all baseband frequencies (60 - 2540 KHz).

Looking again at Graph I, we see that the minimum isolation measured across the entire baseband frequency spectrum using double end grounding, is 100 dB which is better than the 89.77 dB MPI calculated for a 4 baseband cable plant sub-system such as the Hillingdon to Martlesham Heath section. Note that IF repeater sites are not counted in system isolation calculations because they operate at 70 MHz equi-level cable plant conditions.

Graph II shows the Martlesham Heath baseband cable plant to have a minimum isolation of 93 dB at 1.5 MHz. Again, this exceeds our plant requirement by 3.23 dB. A periodic component is again observed in the isolation versus frequency signature of this cable plant. Insufficient testing has been done to date to show specifically why this periodic component exists. It is suspected that the period of these peaks and valleys is related to the length of the baseband cables and the outer shields effectiveness in providing isolation over the baseband frequency spectrum. More investigation should be conducted in this area as elimination of or minimizing this periodic condition could result in significant improvements in the minimum isolation attainable through TRIAX cable plants.

2.6 Crosstalk and Idle Channel Noise

Before we leave the subject of crosstalk, it is required that we see clearly the relationship of crosstalk to idle channel noise.

With or without crosstalk, we can be sure that we will always find a measureable level of idle channel noise (ICN) in a channel. Whether a portion of this ICN comes from crosstalk or not will depend on the isolation of the cable plant and the loading of the system. A cable plant may exhibit relatively poor single tone isolation performance and yet the channels traversing it show good ICN as long as the loading on the system remains light. However, as more groups and supergroups are brought up on line, the idle channel noise climbs. How high it will climb will be dependent to a large extent on the baseband cable plant isolations found throughout the sub-system tested. Because of this inter-relationship of crosstalk, idle channel noise and baseband loading, it is important to make crosstalk and idle channel noise tests during periods of peak loading. The higher the loading, the more reliable the data is for system evaluation of crosstalk and isolation.

3. SYSTEM TESTING AND EVALUATION

3.1 System Testing

Once the baseband cable plant designer/installer has his cable plants on his system/sub-system installed and meeting the isolation requirements he has established as necessary on a per plant basis, he needs to know what he has achieved system wise. Even with a two terminal system, this is not easily accomplished. It takes a couple of good tech controllers at each terminal. They will be fully occupied for an indefinite time depending on how many groups and supergroups are to be tested. A minimum of five channels are required per group and all groups and supergroups common to both

locations and dropping to voice frequency (VF) must be tested. Each channel is tested for receive ICN, test tone level (T/T), and X-talk and then for transmit ICN, T/T and X-talk. This results in 30 tests per group or 150 tests per supergroup. Many channels must be alt-routed during testing with downtime kept to a minimum.

A data sheet arranged for recording the test information is included as attachment 1. This shows the measured data as falling under two columns, Receive and Transmit for Hillingdon. Receive data are the measurements taken at Hillingdon tech control. Transmit data are the measurements taken at Martlesham Heath.

The three pieces of data that we want on each channel receive and transmit are ICN, T/T and X-talk. Let's talk about each in turn to see how they help us evaluate our sub-system.

ICN is what we are most interested in because DCA has established standards for ICN on each circuit. If the links have been properly engineered and the equipments operating properly, we should be able to meet the DCA standard. However, the baseband cable plant has been found to be a source of noise and X-talk in a number of installations and it is not uncommon when this is the case to find the ICN running as much as 12 db higher than the standard. This situation is good in one sense and that is that the degradation caused by the cable plant is so severe that it gets quick attention. The worst situation is where the cable plant degrades the circuits by 3 to 5 dB and the maintenance people spend countless hours testing and aligning radio and multiplex equipments looking for that little extra performance needed to meet the standard. So this is really what it's all about, we

want to meet the ICN established for our circuits. It takes a lot of individual tests to let us see what our ICN looks like over our baseband frequency spectrum but they are a must. Just as the cable plant isolation may vary widely as a function of frequency, the ICN also varies from channel to channel, group to group and supergroup to supergroup. We want to meet DCA standards. Of course there may be a problem such as a local broadcast station sitting right on a channel. A well installed baseband cable plant may help the situation, but only so much can be expected. Also, the local station may be getting into the multiplex equipment in the group/supergroup wiring. But on the avergage, if all is well with our system, the ICN will meet standards across the whole baseband with very few exceptions and these should be identifiable.

T/T is our channel test tone level. This information is needed in order that we can normalize our ICN and X-talk data. We need this correction to compare data. For example, if the T/T is -8 dBm0, then we must subtract 2 dB from both ICN and X-talk in order to compare them with data taken with a T/T of -10 dBmo.

X-talk lets us make a guess as to what will happen to ICN should the system loading increase significantly. If we have an ICN of -64 dBm0 and a X-talk of -57 dBm0 on a lightly loaded system, we don't feel as secure as when we have an ICN of -64 dBm0 and a X-talk of 63 dBm0. In both instances, we are currently meeting DCA X-talk requirements but not under fully loaded conditions. It is not difficult to attain low values of ICN on lightly loaded systems but as the loading increases, the ICN can increase severely if system isolation is poor.

Once we have completed our system tests and normalized our data, we are ready to assess just how well our baseband cable plants are performing. Looking at the data can tell us a good deal about each of the two terminals we have been testing.

3.2 Data Evaluation

Hillingdon's receive data provides an assessment of the Martlesham Heath radio, multiplex and baseband cable plant. (For the purpose of this example, we are ignoring the relays between Hillingdon and Martlesham Heath.) In turn, Hillingdon's transmit, which is Martlesham's receive, assesses Hillingdon's radio, multiplex and baseband cable plant. This relationship is often misunderstood and facilities having high receive noise levels are charged with responsibility for clearing the problem at their location. Obviously, no amount of in-house effort will correct the problem as its source is at the distant transmit site or intermediate facilities. The relative levels of the receive/transmit signals on the receiving stations baseband cable plant are such that the noise effect of ground loop currents and crosstalk is negligible when compared with the noise effect of the same problems in the transmit cable plant.

Plotting out the X-talk measurements made at the receive facility and comparing them with the plots of isolation made for the distant cable plant will quickly reveal problems existing in intermediate relay facilities. Adding 30 dB to each value of crosstalk measured at the receive facility will convert the X-talk plot into a similated isolation plot which should compare within a few dB of the distant end cable plant isolation graphic results. When large variations are apparent, an investigation of the intermediate

facilities is called for. Standard baseband cable isolation tests should be made at these relays and the graphed results compared with the data previously obtained at the receive location. The facility having the faulty cable plant should become readily apparent. Thereafter, procedures described earlier in this report can be used to clear the problem and test the cable plant to confirm its proper operation.

4. INITIAL INSTALLATION

We see in Fig 8 the interface between AN/UCC-4 multiplex and either a LC-4/8 or AN/TRC-150 radio. The hybrid output and span pad float above ground and utilize the center conductor and inner shield of a triax cable to carry the baseband information to the wideband patch bay and hence to the radio. At no point in this path does the center conductor or inner shield contact ground until arriving at the radio where the inner and outer shield are combined and grounded through the radio BNC connector. At the multiplex combining panel, the outer shield of the triax cable is connected to the equipment ground terminal provided at the rear of the combining panel. Prior to installing the BNC connector at the radio, ohmmeter measurements may be used to insure that no grounding condition exists on the center conductor or inner shield and the outer shield as required. Should the inner shield show a ground condition, the X-Y interconnects on the combining panel should be checked to see that they are not cross connected. The X-Y connection is usually made to the bottom of the looping plug shield solder

tabs and may be cut and taped back. The MUX and RADIO looping plugs at the wideband patch bay can be removed and thereby isolate sections of the baseband cable to see where shorts or opens take place. Troubleshooting is simple and straightforward as long as the installer understands the principles of the baseband cable plant theory.

Figure 9 is a sketch of the Siemens' V 60/120 to LC-4/8 radio baseband cable plant. Siemens' 150/75 ohm impedance matching transformers are used to match to the triax cable. Solder terminals are provided on the transformer with a grounding option for the outer shield. Inner shield and center conductor are connected to a floating (isolated) output winding also through solder connections. Here we have a difference in transmit levels provided to the wideband patch bay. The AN/UCC-4 provided us with -45/-15 dBm transmit/receive levels whereas the V60/120 output is -15/-15 dBm. The transmit is dropped by a TRIAX pad installed at the wideband patch thus providing proper transmit levels (-45 dBm) at the wideband patch bay. Troubleshooting suggestions provided above apply equally well to this baseband cable plant. Again, outer and inner shields ground together at the radio BNC connector.

5. BASEBAND BRIDGES

Baseband bridges deserve special consideration because they vary in their input/output connection methods. Some utilize TRIAX jacks; however, most bridges installed on the Scope Comm system use open, unshielded terminal strip connections. Signal ground is usually seperate from equipment ground and the bridge is treated in exactly the same manner as multiplex. We should always see a float-

ing output at the bridge driving the single ended input of the radio. The outer shield is grounded at the bridge equipment ground connection with outer shield grounding at the radio. When using terminal lugs or solder connections to interface the baseband cable into a bridge, care must be taken to see that the shields on the cable do not short together and that as little as possible of the center conductor is left unshielded as very short sections of unshielded cable can cause large losses in cable plant isolation at baseband frequencies.

One further consideration on baseband bridges is that interaction does take place between the various ports of the bridge on operational systems. A faulty baseband cable plant on say the north port of a four way bridge can have a severe effect on the east port. The effect can be all out of proportion to the degradation caused on the northern system. Because of this interaction between bridge ports, testing in all directions must be accomplished before and after corrections are made to bridge cable plants to insure that some unsuspected portion of the system has not been degraded while attmepting to improve another.

6. ENVIRONMENTAL PROTECTION

Use of tactical radio and multiplex shelters in fixed plant configurations has resulted in special problems associated with baseband cable plants. Often as not, the installers utilize overhead guy wires to support baseband cables from pole mounted splice boxes to

the bulkhead connectors on the shelters. These cables whip about during high winds causing shields to loosen and fray thus posing a constant threat of intermittent outages and performance fluctuations. This type of condition develops gradually and is extremely hard to troubleshoot. In addition, the triax bulkhead connectors utilized on Scope Comm shelters for baseband cable entrance ground the outer cable shield which can result in ground loop currents and severe isolation losses.

The pole mounted splice box represents another problem area as it is utilized for splicing one type of shielded baseband cable to another. Connectors or video cable splicing techniques may be used here but run the danger of isolation losses, connector failure and corrosion of electrical contact surfaces. For reasons previously discussed, it is best to use one continuous run of baseband cable from the wideband patch bay to the input/output radio connectors. This eliminates sleeper type problems and provides the simplest and best cable plant. Conduit and underground duct work can be used between the multiplex building or shelter and the radio shelter. The cabling should be enclosed in a continuous run of plastic tubing to protect it from moisture. This installation technique was used at Hillingdon and Martlesham Heath. Both baseband cables were enclosed in continuous runs of direct burial plastic tubing which enters both the radio shelters and multiplex buildings. Unused waveguide ports were utilized for conduit entrances on the shelters. Should a moisture accumulation be suspected in the plastic tubing, warm, dry air can be blown through the tubing to insure dryness.

It must be emphasized that hanging of baseband cables from guy wires for long periods of time is to be discouraged for the reasons cited above as well as for the unwarrented exposure of the cables to damage by falling tree limbs, ice, ice formations and general deteri-oation of the cables, connectors and jacks.

7. BASEBAND CABLE PLANT PSYCHOLOGY AND TROUBLESHOOTING

7.1 Psychology

Although this paper is dedicated to being a "How to do it right the first time" and "How to fix it up now that it's been done wrong" type article, it would be unwise not to stress at this point that troubleshooting baseband cable plants involves a special mentality. Baseband cable plants are usually carrying mission traffic. Site commanders bear the burden of responsibility for seeing that nothing interferes with this flow of traffic through their sites. Although that poorly performing baseband cable plant may not be doing all it can, it still is operating and no responsible site commander is about to gamble with loosing a link or system through unauthorized outages. Yet, that is exactly the degree of risk involved in locating and correcting the problem. And to further complicate things, the best and only realistic way to troubleshoot baseband cable plants is while they are loaded with operational traffic. What this means is that the troubleshooter must be a person with a strong sense of responsibility; a person that the site commander feels confidence in. From the moment the troubleshooter first places his hands on the site equipments, he must work as a team member with the local site mainte-nance personnel fully informing them of what he is doing as well as

what he is trying to accomplish. The second group of site people he must have on his team is the tech control personnel. They will be doing his system noise and crosstalk testing in addition to their normal workload. The data they provide will be used to evaluate the performance of the baseband cable plant; therefore, it must be accurate and taken according to a set procedure. Hundreds of individual tests may be required and these may be repeated several times over. The novelty wears off quickly.

What does all this add up to? Pressure on the troubleshooter. He must plan his testing thoroughly and organize the effort required to implement it. Often test results will be disappointing and frustrating. It will seem that there just isn't any way possible to make that cable plant perform as it should. There is a strong temptation to rationalize and say "Maybe we are getting all we can out of this equipment" or "That station ground system is the REAL cause of the problem." This is where determination and perserverance really count. The troubleshooter is there to do a complex job. He is utilizing considerable manpower resources. This may be the only opportunity for the site to get these baseband cable plant problems corrected for a long time to come. If he quits, a lot of hard work by a lot of people is thrown away. If he stays on the job until he solves the problem, the increased performance in the system will be a source of pride and accomplishment to all who participated. The troubleshooter is then ready to tackle his next baseband cable plant with a confidence born from success. The going may not get easier, but he knows he can do it if he sticks to the rules outlined in this paper.

7.2 Troubleshooting the Baseband Cable Plant

Techniques have already been provided for facility and system testing the baseband cable plant but it is well to list the defects found to date:

1. At the top of the list we have to place improper TRIAX connector and BNC connector assembly. Defects are: shields not continuous through connectors; center conductors not soldered, or twisted off during connector assembly; and shorting together of outer and inner shields through lack of understanding of cable installation requirements.

2. Connection of the X-Y strapping in the AN/UCC-4 combining panel. This has caused ground loops in the baseband cable plants and in one instance severe crosstalk between adjacent multiplexes (Hillingdon North and East systems).

3. Improper selection of single ended versus double ended grounding of the outer shields. As shown in Graphs I and II, this factor can result in profound differences in plant isolation.

4. Poor isolation of radio and/or multiplex interface components. Variations from know configurations of input/output interface components or equipments should be tested to insure that they display a sufficiently high degree of isolation to insure that the absolute isolation of the baseband cable plant meets facility requirements (MPI).

8. CONCLUSION

The information provided in this report is empirical in nature; the procedures, mathematics and test techniques cited fill an immediate

need in the area of engineering, installation and troubleshooting of baseband cable plants. With this report as a guide, it is now possible to systematically investigate previously installed baseband cable plants and correct them as required. That substantial improvements can be made in presently installed systems has been well established by the progressive reduction of idle channel noise and crosstalk demonstrated on the Hillingdon North sub-system as corrections were made to its baseband cable plants.

Inspection of other wideband facilities such as Feldberg, Langerkopf and Rhein Main has shown the same installation defects discussed in this report as currently existing. It remains for a team to be trained in the troubleshooting procedures outlined herein and a vigorous program of baseband cable plant discrepancy clearance to be initiated on a facility by facility basis. It will not be sufficient to clean up just Air Force cable plants; Army must be fully involved as well. We are concerned here with a system and we are dependent on Army facilities to carry our traffic. It is readily apparent that DCA must function as a coordinating activity and that a long term plan of action is required in order to insure that the best possible performance is being provided by existing facilities.

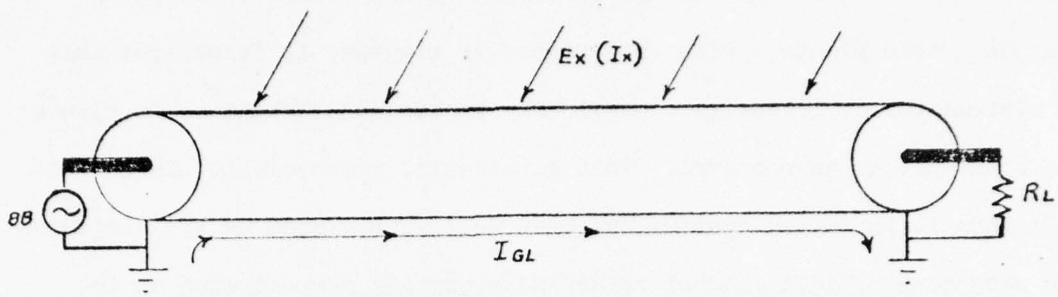


FIGURE 1a.

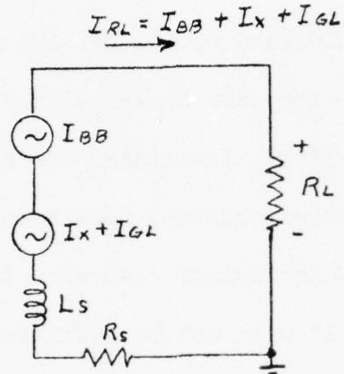


FIGURE 1b.

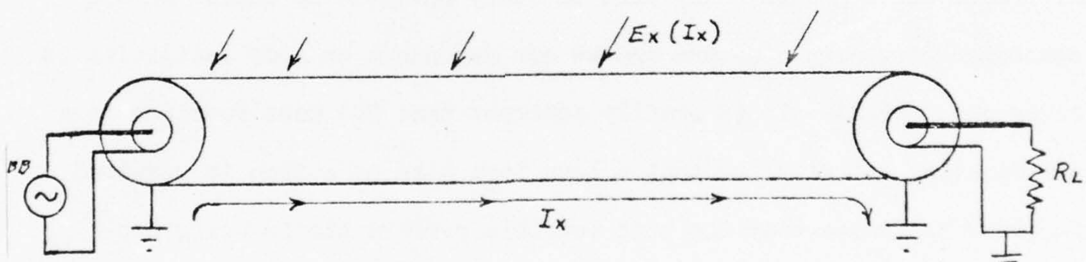


FIGURE 2a.

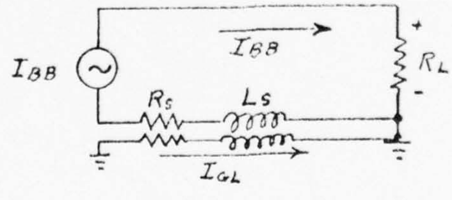


FIGURE 2b.

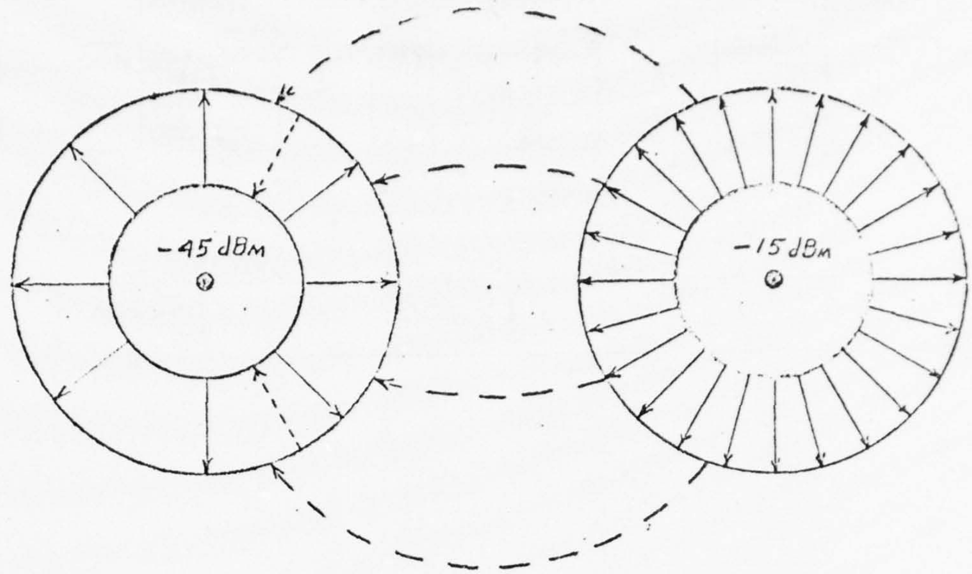


FIGURE 3

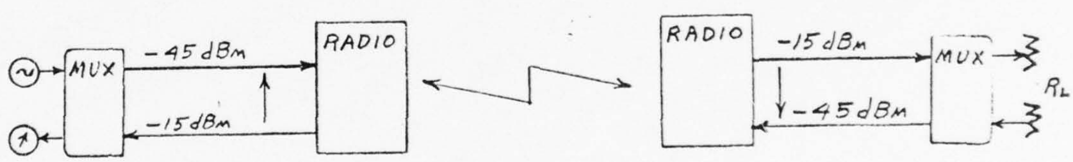


FIGURE 4

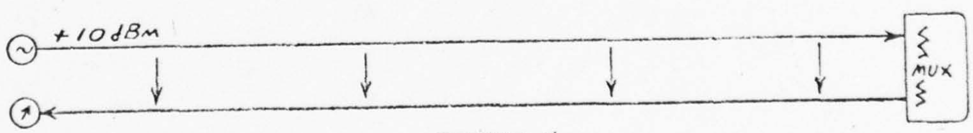


FIGURE 5

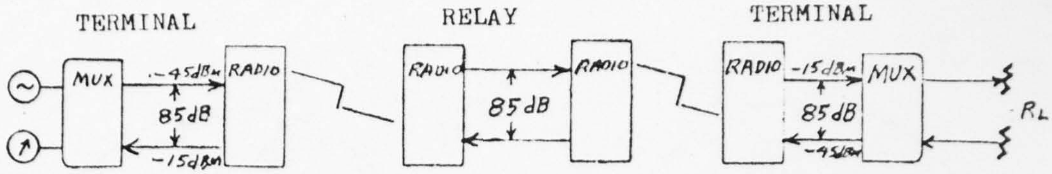


FIGURE 6

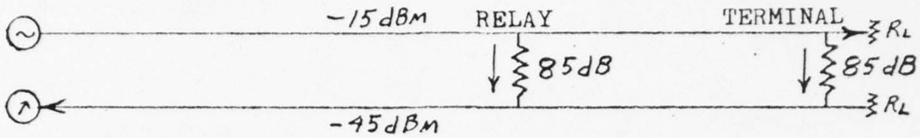


FIGURE 7

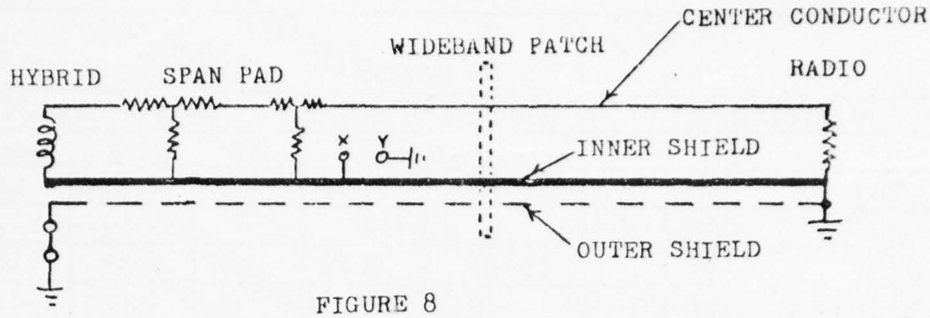


FIGURE 8

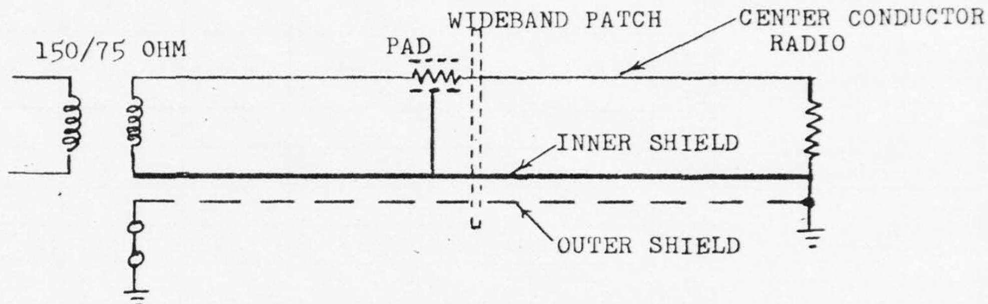


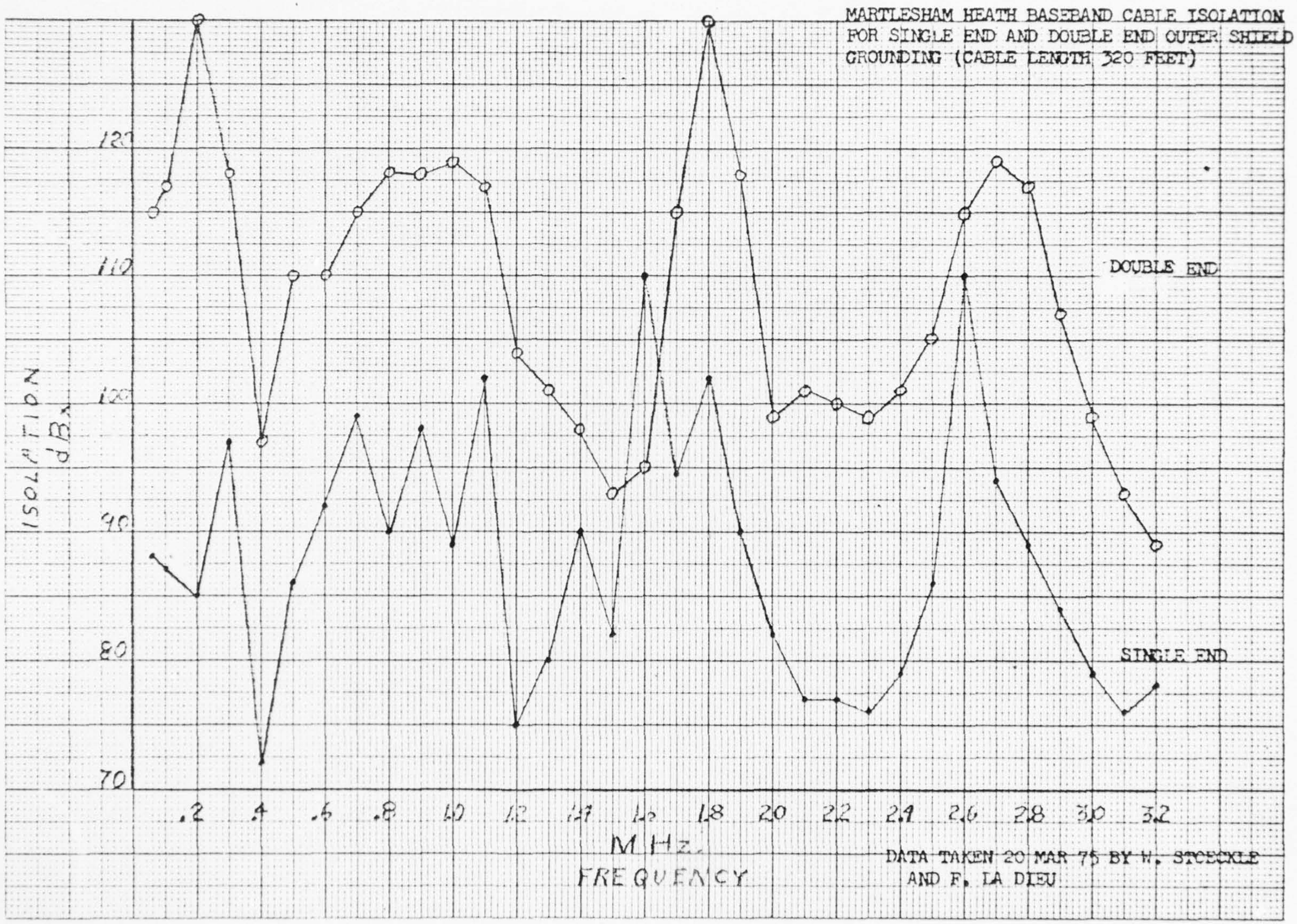
FIGURE 9

BB CABLE TESTING PROGRAM FOR Hillingdon

FROM Hillingdon TO Martlesham Heath DATE 29 Aug. 75 TIME 1300

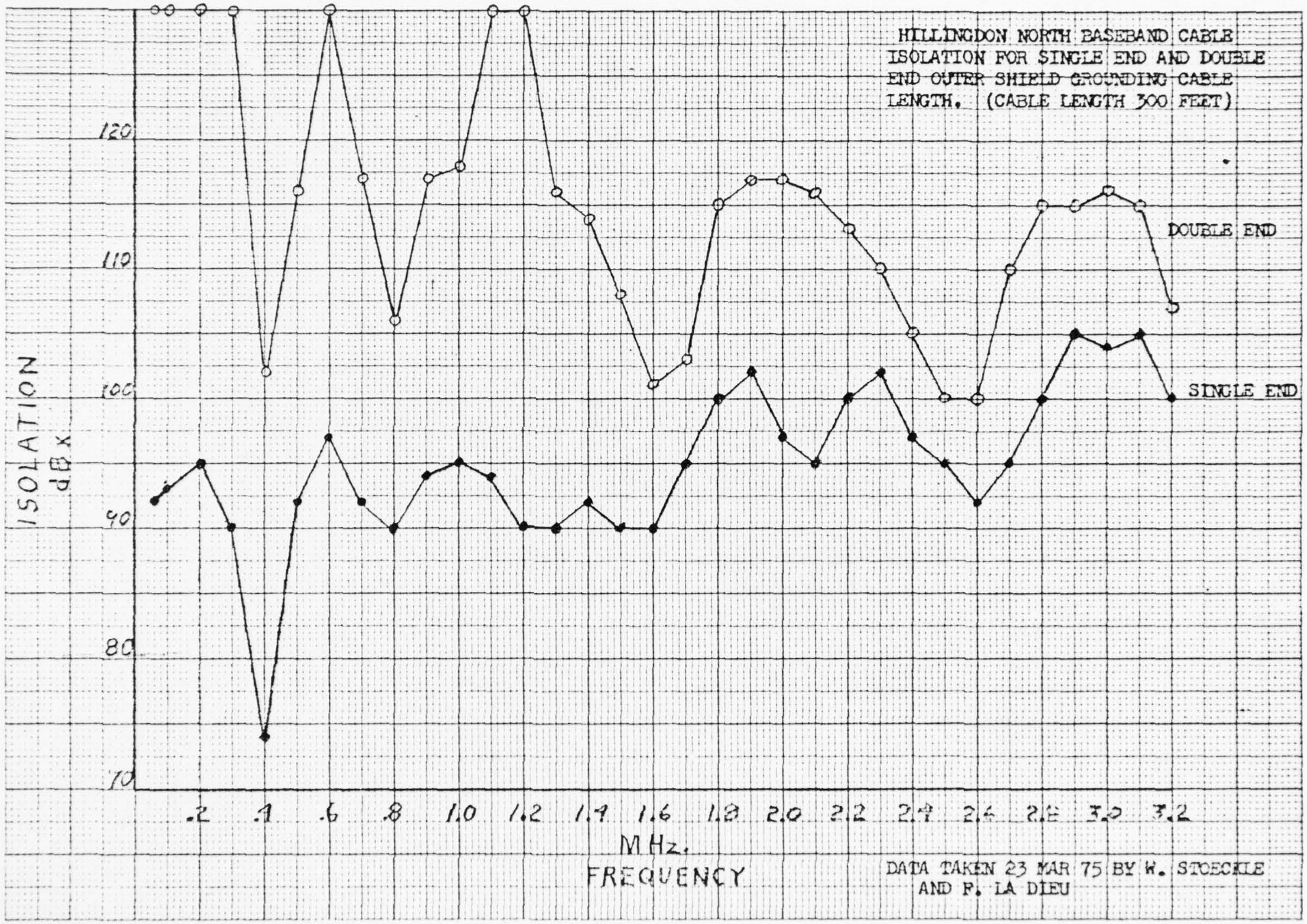
		Receive (3kc)				Transmit (3kc)		
GROUP	CH.	ICN dBm0	T/T	X- TALK		ICN dBm0	T/T	X-TALK
3/1	01	- 62	-9	60		- 64	-12	62
	04	- 58	-8	58		- 63	-10	62
	07	- 64	-10	63		- 62	-11	61
	10	-63	-9	62		-60	-10	59
	12	-60	-7	59		-63	-10	62
3/2	01	-64	-10	63		-63	-11	60
	04							
	07							
	10							
	12							
3/4	01							
	04							
	07							
	10							
	12							
5/2	01							
	04							
	07							
	10							
	12							
	01							
	04							
	07							
	10							
	12							
	01							
	04							
	07							
	10							
	12							
	01							
	04							
	07							
	10							
	12							

DATA PROVIDED FOR ILLUSTRATION ONLY



MARTLESHAM HEATH BASEBAND CABLE ISOLATION FOR SINGLE END AND DOUBLE END OUTER SHIELD GROUNDING (CABLE LENGTH 320 FEET)
DOUBLE END
SINGLE END
ISOLATION dB
120
110
100
90
80
70
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
MHz
FREQUENCY
DATA TAKEN 20 MAR 75 BY W. STOECKLE AND F. LA DIEU

GRAPH II


HILLINGDON NORTH BASEBAND CABLE ISOLATION FOR SINGLE END AND DOUBLE END OUTER SHIELD GROUNDING CABLE LENGTH. (CABLE LENGTH 300 FEET)
DOUBLE END
SINGLE END
ISOLATION
dB x
120
110
100
90
80
70
MHz.
FREQUENCY
DATA TAKEN 23 MAR 75 BY W. STOECKLE AND F. LA DIEU

GRAPH I

APPENDIX B

TRIAX
BASEBAND CABLE PLANT DATA

DISTRIBUTION: X

603 TCS	5
2134 CS	5
HQ AFCS	
CS	2
OA	2
DOY	2
LGM	2
XPQ	2
EPE	2
EPCP	1
DAPL	5
NCA/EPE	5
SCA/EPE	5
PCA/XME	5
ECA/XPQ	5
1839 EIG/EPE	5
DDC, CAMERON STATION, ALEXANDRIA, VA	2
1842 EEG/EEISD	20
1842 EEG/EETTW	40
2130 Comm Gp/LG	5
1945 Comm Gp/LG	5
DCA/Code 500	5
DCEC	
R320	5
R200	5
R400	5
R700	5
DCA-EUR/E102	5
USACC/ACC-OPS-ST	10
COMMNAVTELCOM	5
CINCUSNAVEUR	2

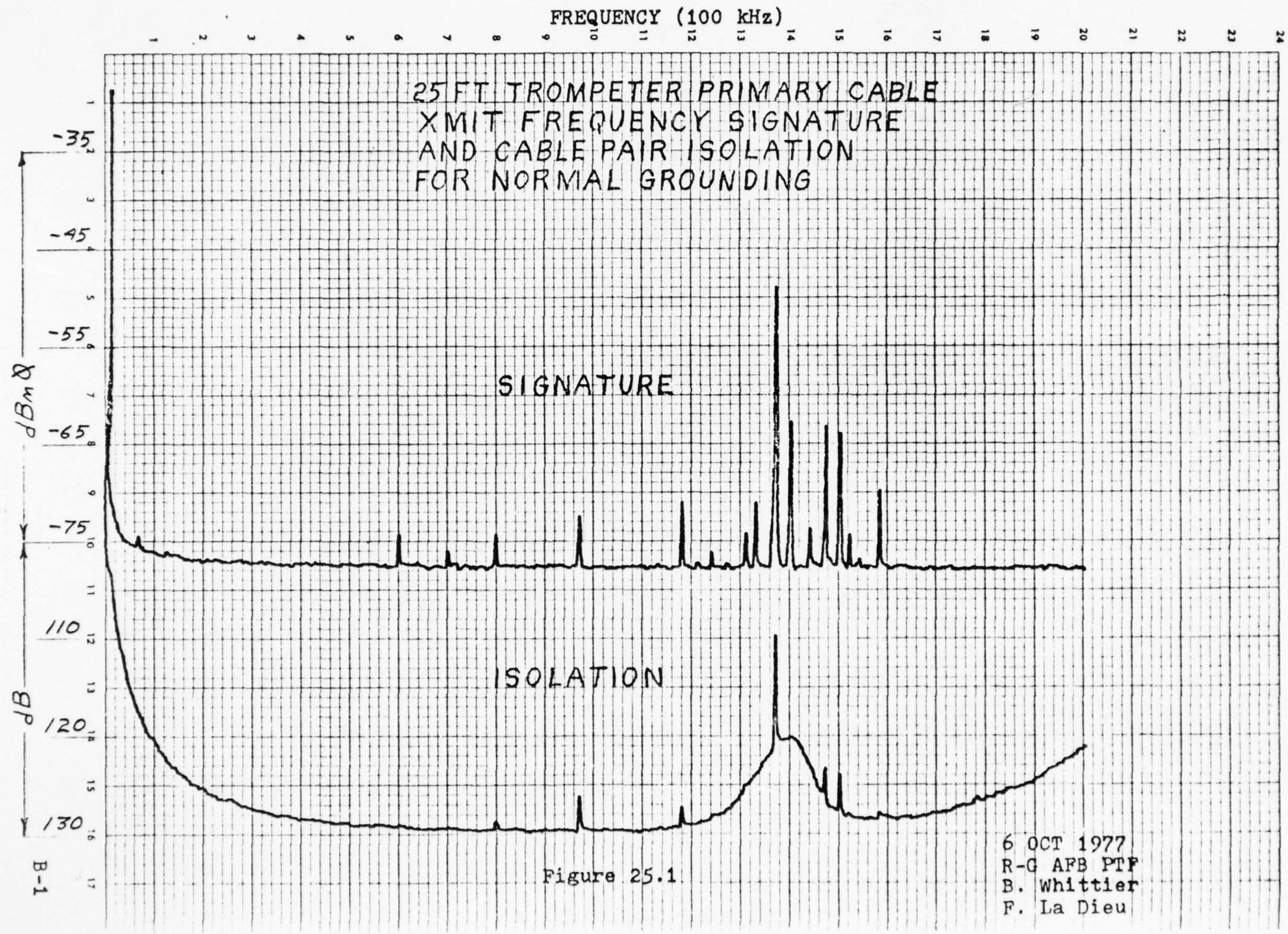

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
AND CABLE PAIR ISOLATION
FOR NORMAL GROUNDING
SIGNATURE
ISOLATION
-35
-45
-55
-65
-75
dBm0
110
120
130
dB
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.1

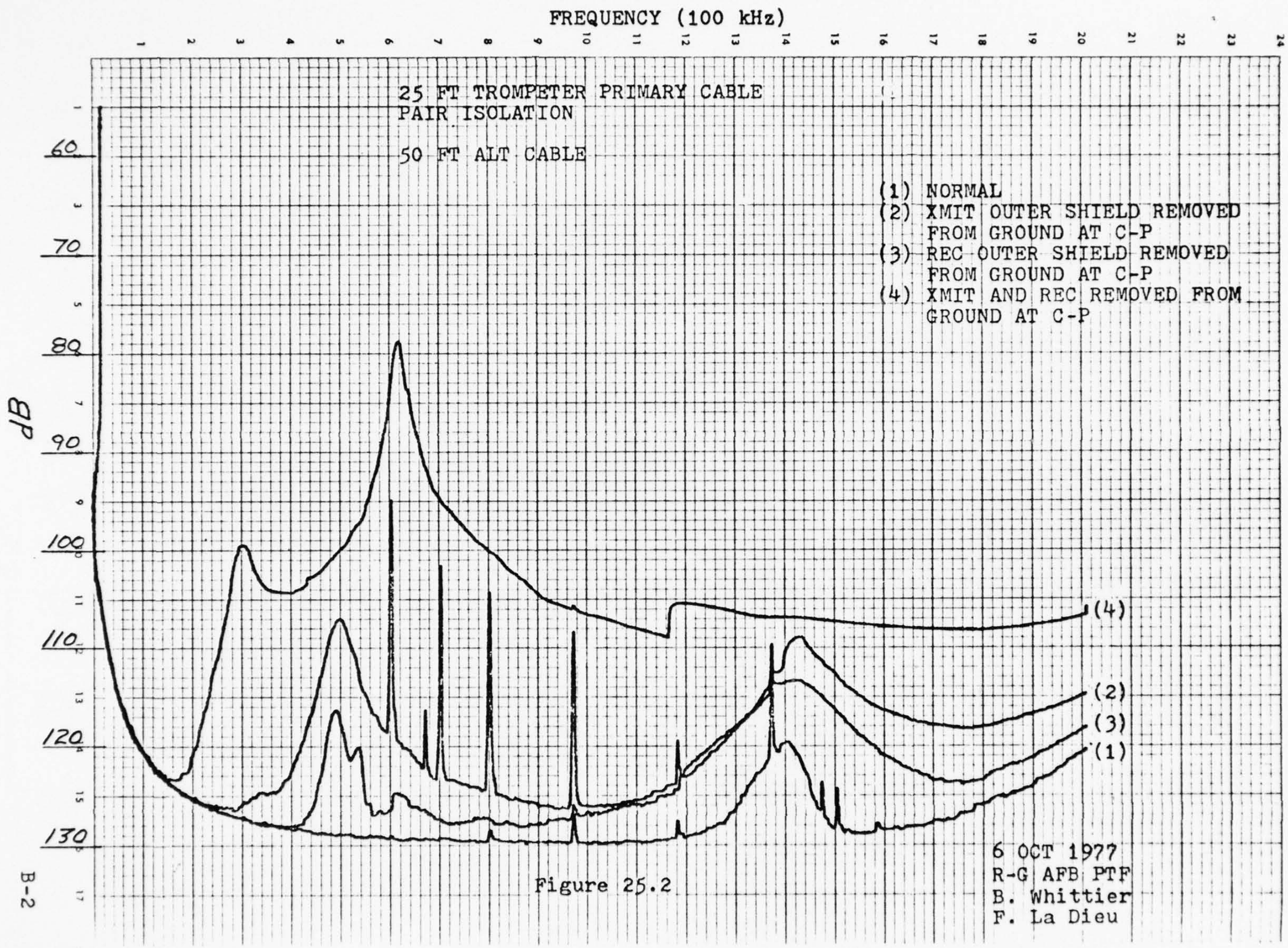

FREQUENCY (100 kHz)
dB
60
70
80
90
100
110
120
130
25 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
50 FT ALT CABLE
(1) NORMAL
(2) XMIT OUTER SHIELD REMOVED FROM GROUND AT C-P
(3) REC OUTER SHIELD REMOVED FROM GROUND AT C-P
(4) XMIT AND REC REMOVED FROM GROUND AT C-P
(4)
(2)
(3)
(1)
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.2

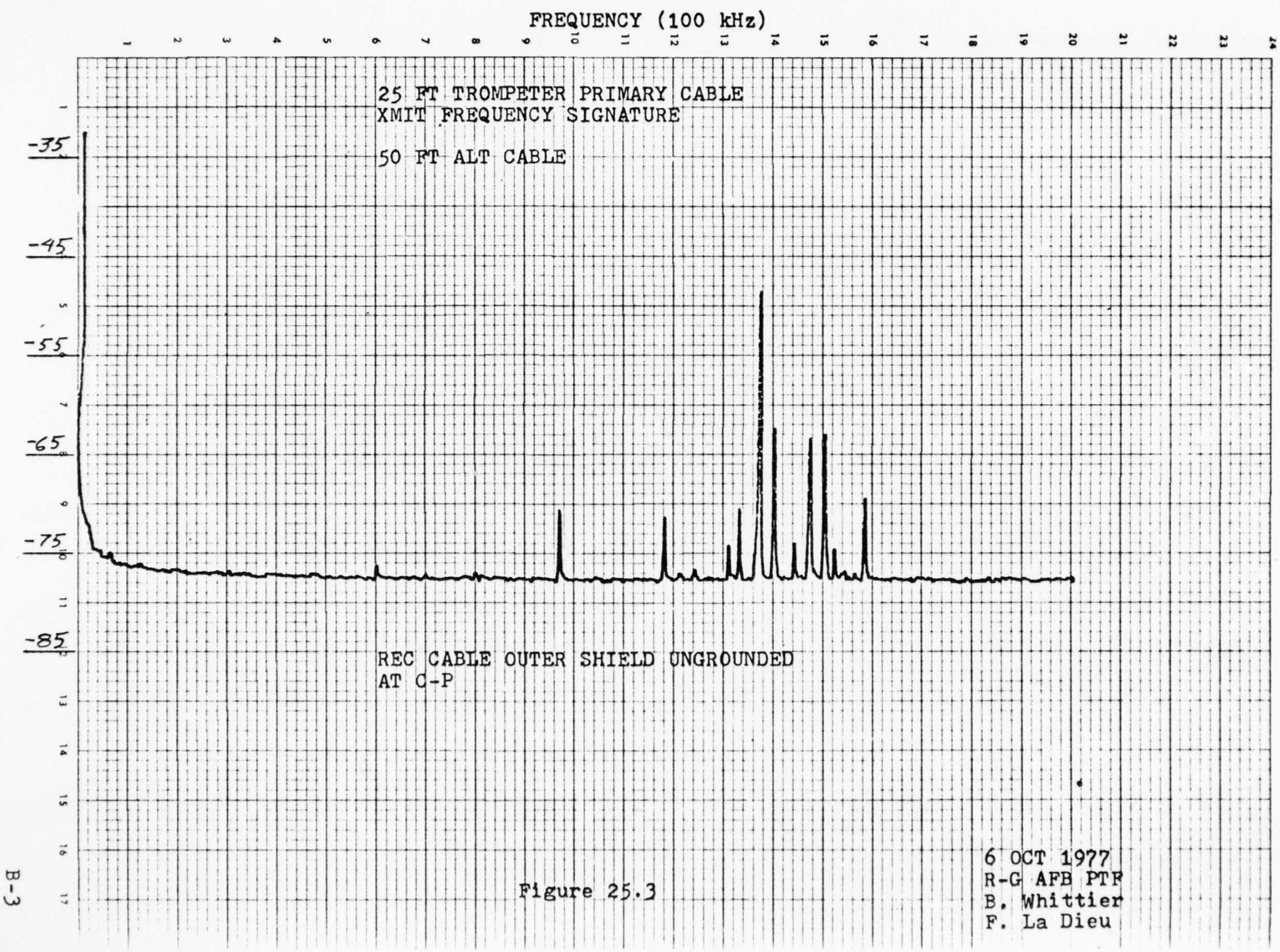

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLE
REC CABLE OUTER SHIELD UNGROUNDED
AT C-P
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu
-35
-45
-55
-65
-75
-85

Figure 25.3

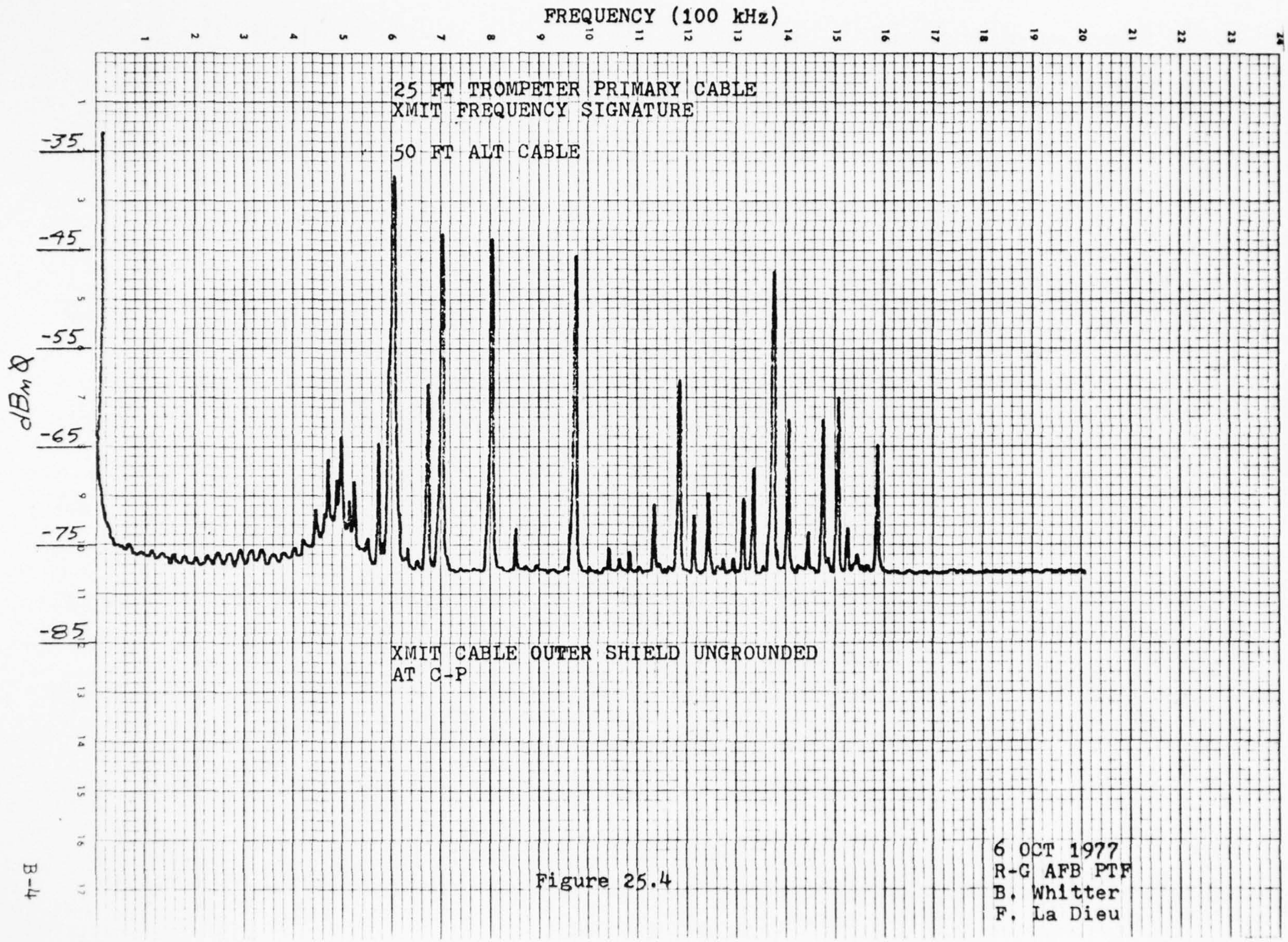

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLE
XMIT CABLE OUTER SHIELD UNGROUNDED
AT C-P
dBm Ø
-35
-45
-55
-65
-75
-85
6 OCT 1977
R-G AFB PTF
B. Whitter
F. La Dieu

Figure 25.4

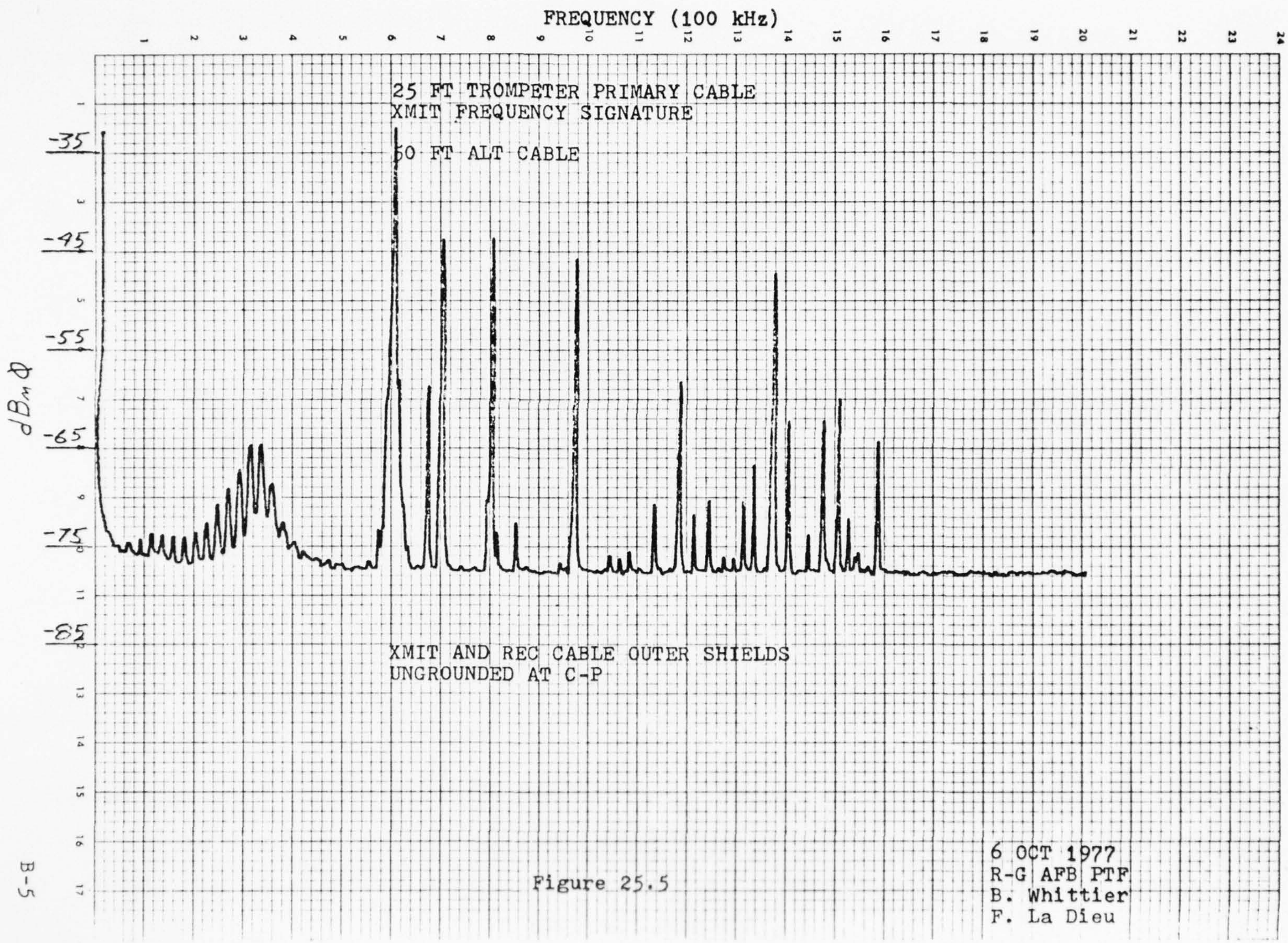

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLE
XMIT AND REC CABLE OUTER SHIELDS
UNGROUNDED AT C-P
dBm Φ
-35
-45
-55
-65
-75
-85
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.5

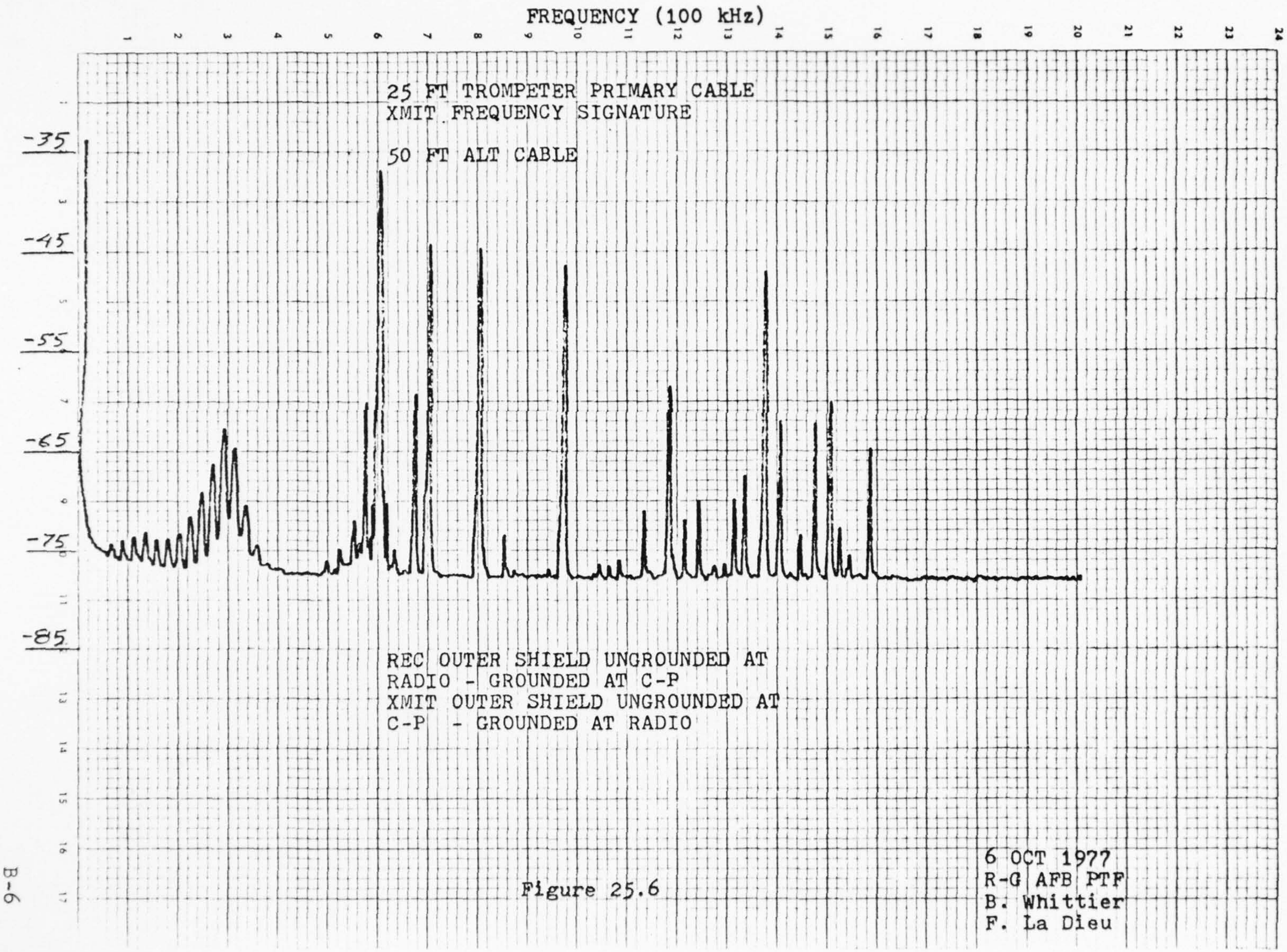

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLE
REC OUTER SHIELD UNGROUNDED AT
RADIO - GROUNDED AT C-P
XMIT OUTER SHIELD UNGROUNDED AT
C-P - GROUNDED AT RADIO
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu
-35
-45
-55
-65
-75
-85

Figure 25.6

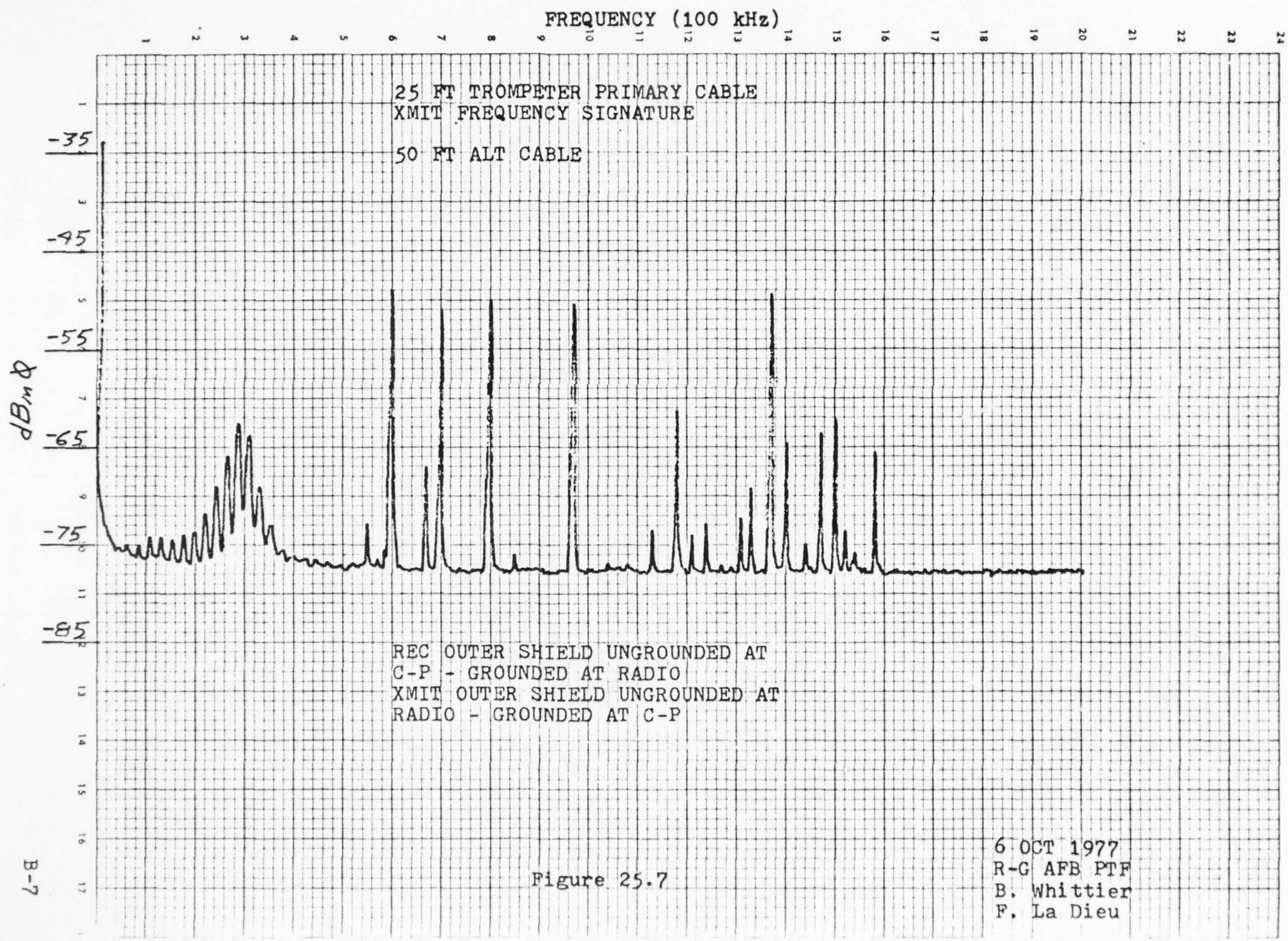

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLE
dBm
-35
-45
-55
-65
-75
-85
REC OUTER SHIELD UNGROUNDED AT C-P - GROUNDED AT RADIO
XMIT OUTER SHIELD UNGROUNDED AT RADIO - GROUNDED AT C-P
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.7

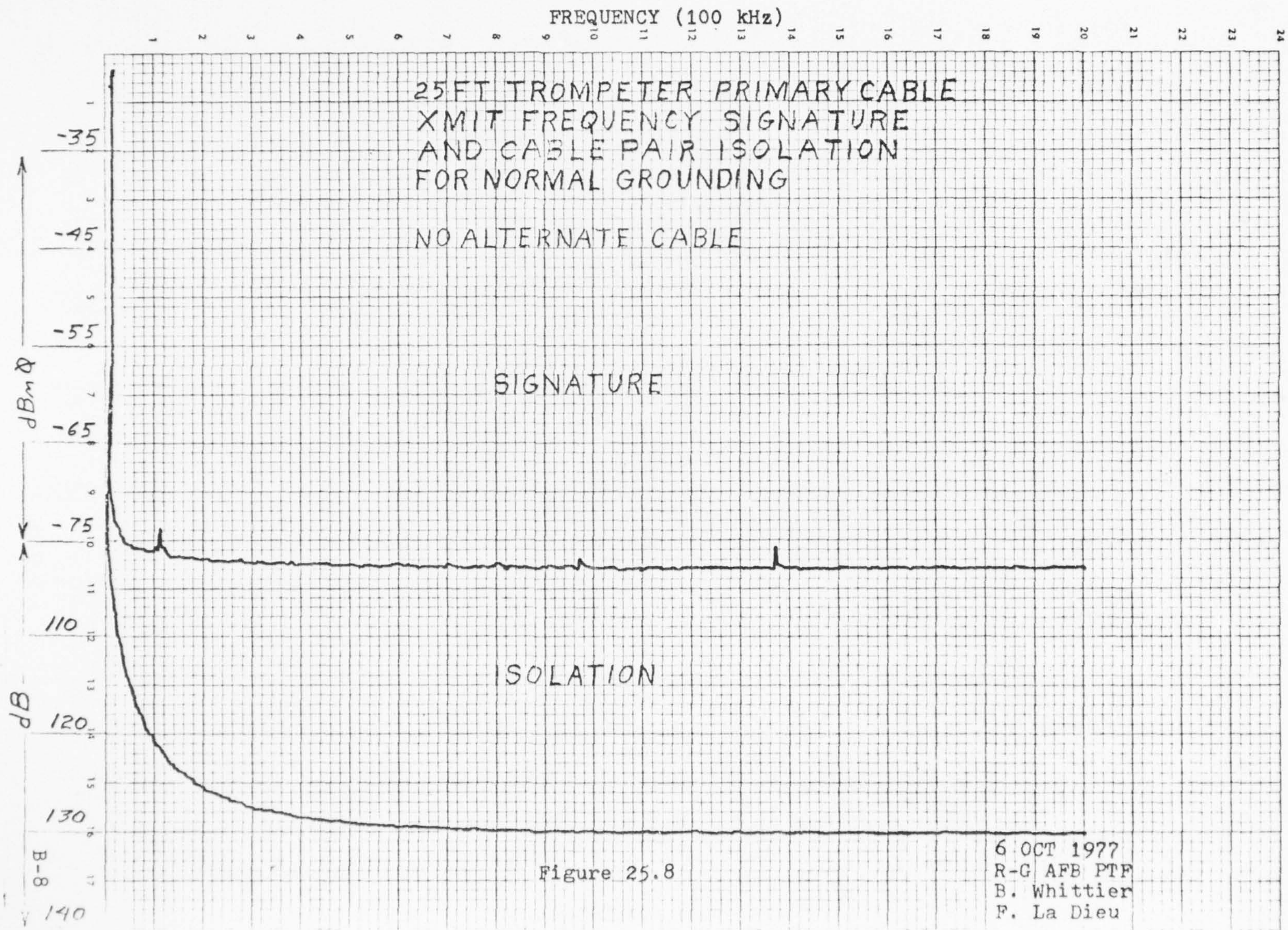

FREQUENCY (100 kHz)
25FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
AND CABLE PAIR ISOLATION
FOR NORMAL GROUNDING
NO ALTERNATE CABLE
SIGNATURE
ISOLATION
dBmØ
dB
-35
-45
-55
-65
-75
110
120
130
140
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.8

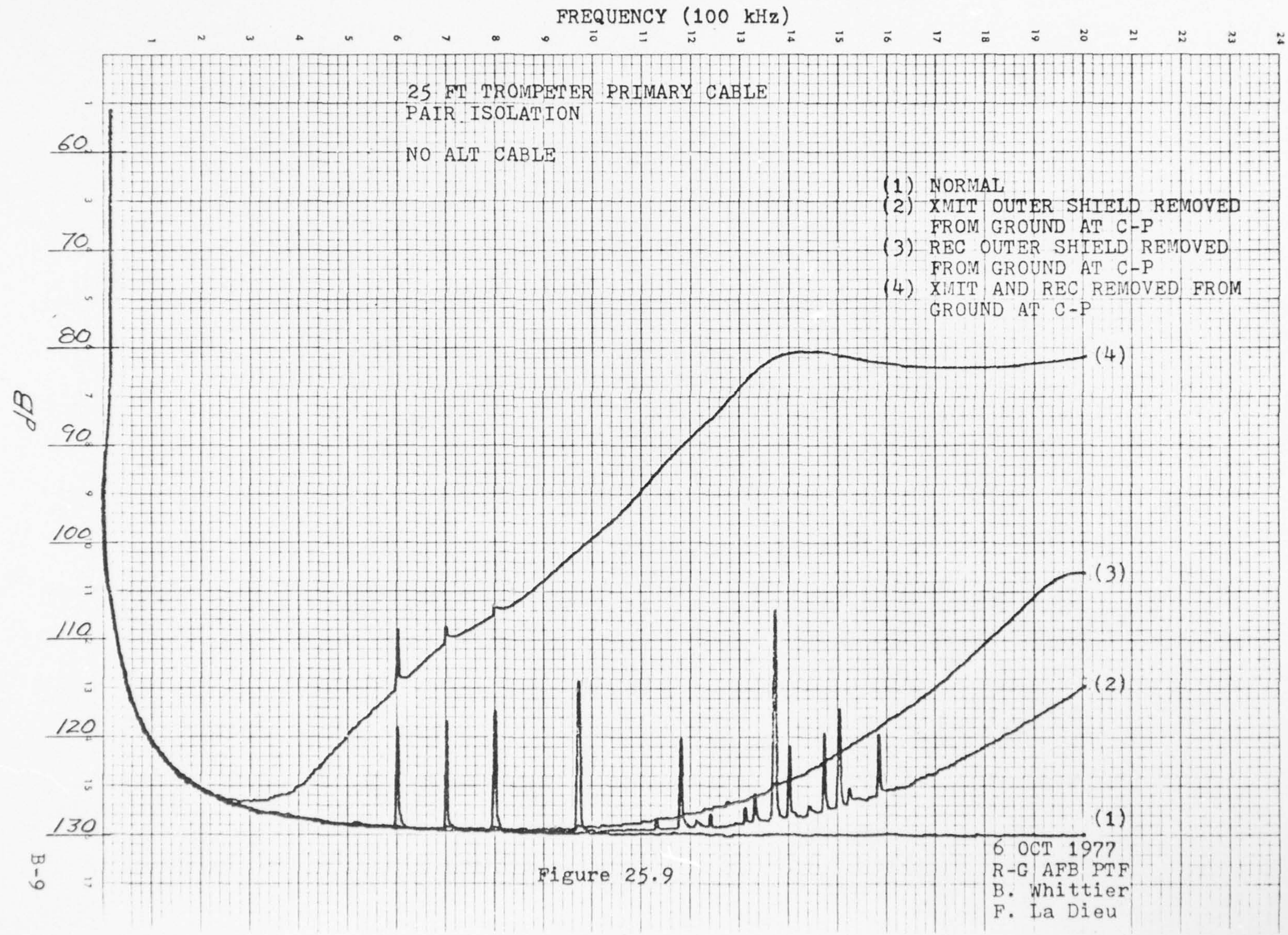
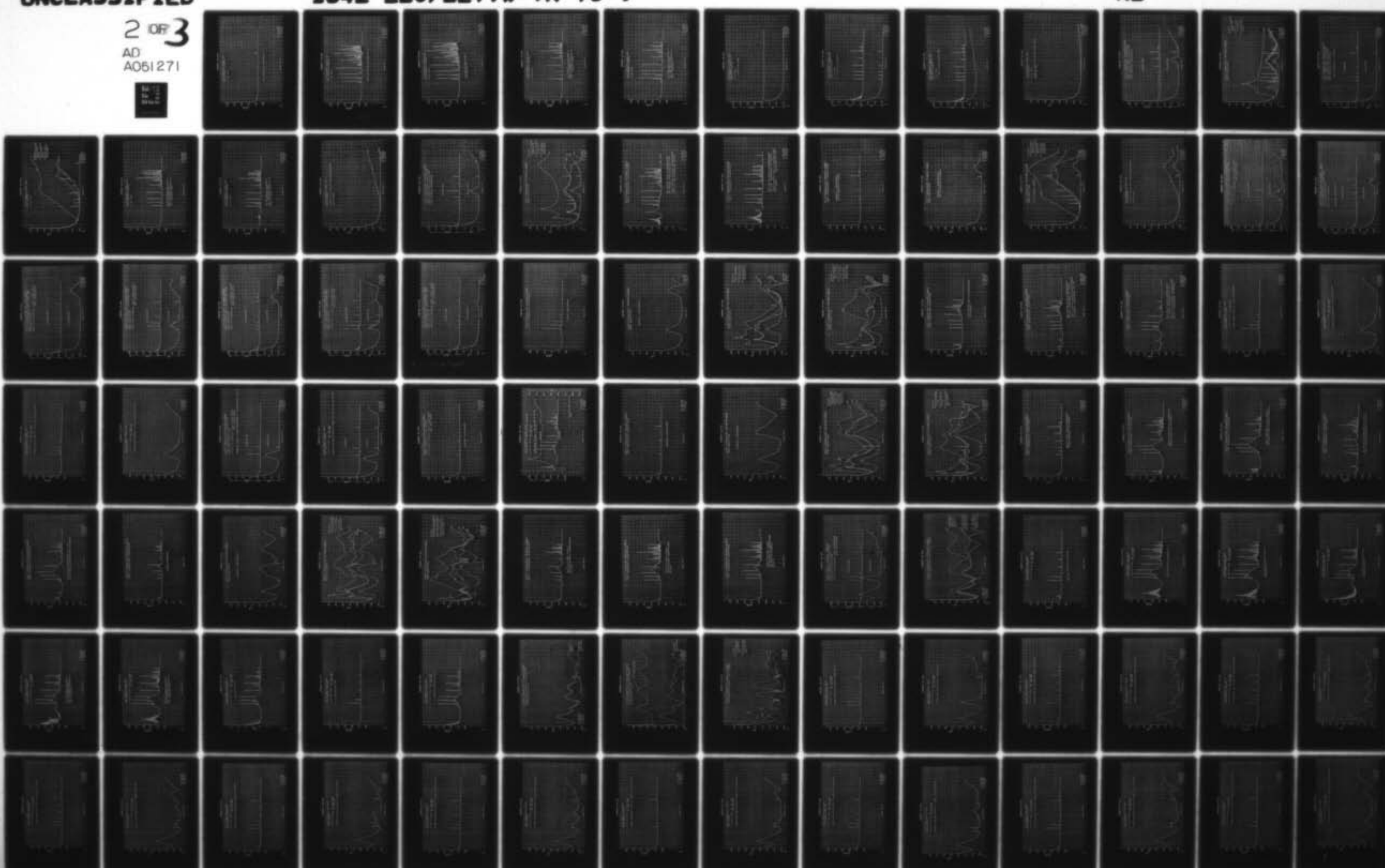

FREQUENCY (100 kHz)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
dB
60 70 80 90 100 110 120 130
25 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NO ALT CABLE
(1) NORMAL
(2) XMIT OUTER SHIELD REMOVED FROM GROUND AT C-P
(3) REC OUTER SHIELD REMOVED FROM GROUND AT C-P
(4) XMIT AND REC REMOVED FROM GROUND AT C-P
(4)
(3)
(2)
(1)
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.9

AD-A051 271 ELECTRONICS ENGINEERING GROUP (1842ND) SCOTT AFB IL F/G 17/2
FREQUENCY DIVISION MULTIPLEX BASEBAND CABLE PLANT PERFORMANCE I--ETC(U)
FEB 78 F LA DIEU
UNCLASSIFIED 1842 EEG/EETTW-TR 78-9 NL

2 OF 3
AD
A051271



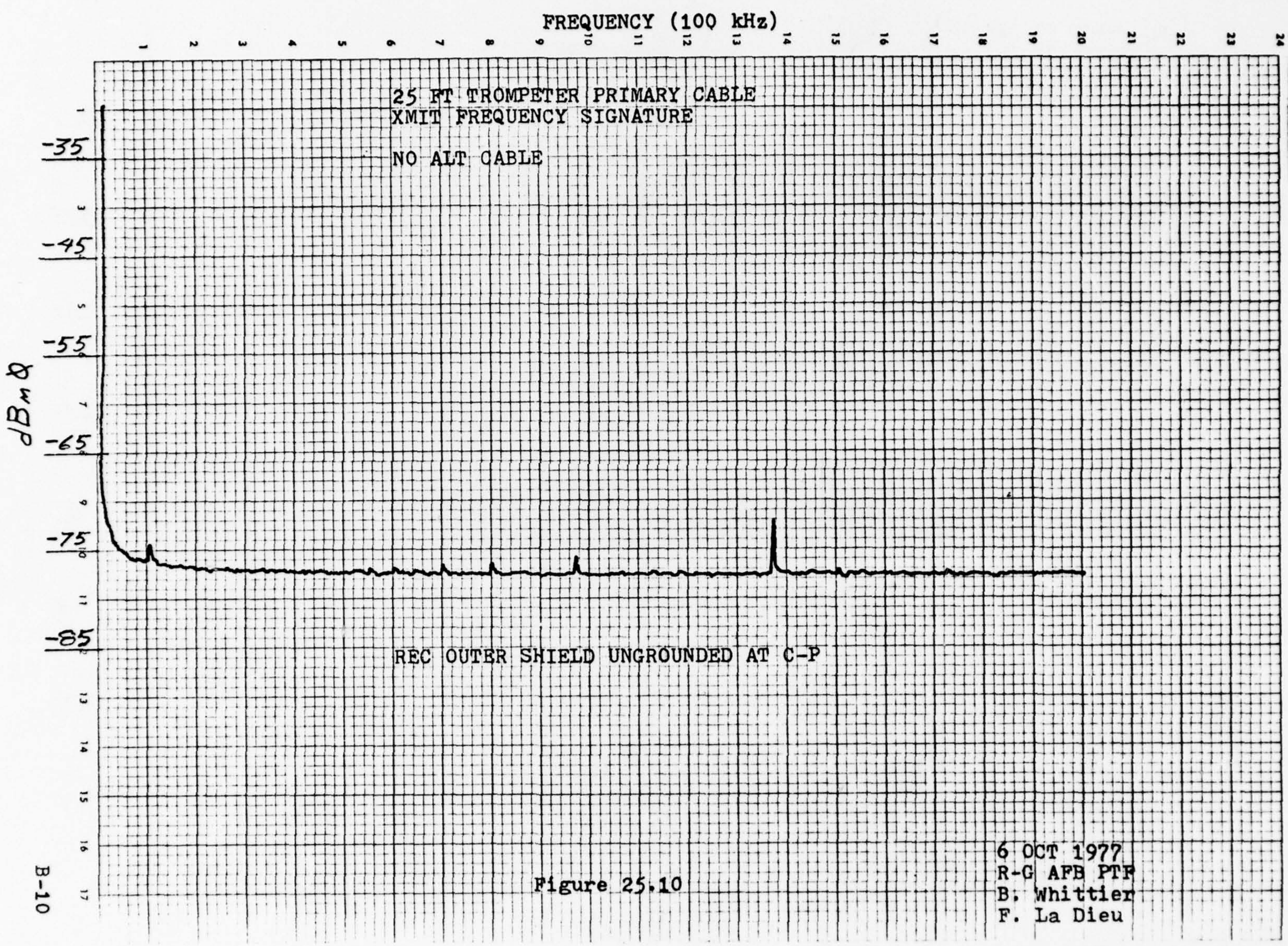

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NO ALT CABLE
REC OUTER SHIELD UNGROUNDED AT C-P
dBm0
-35
-45
-55
-65
-75
-85
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.10

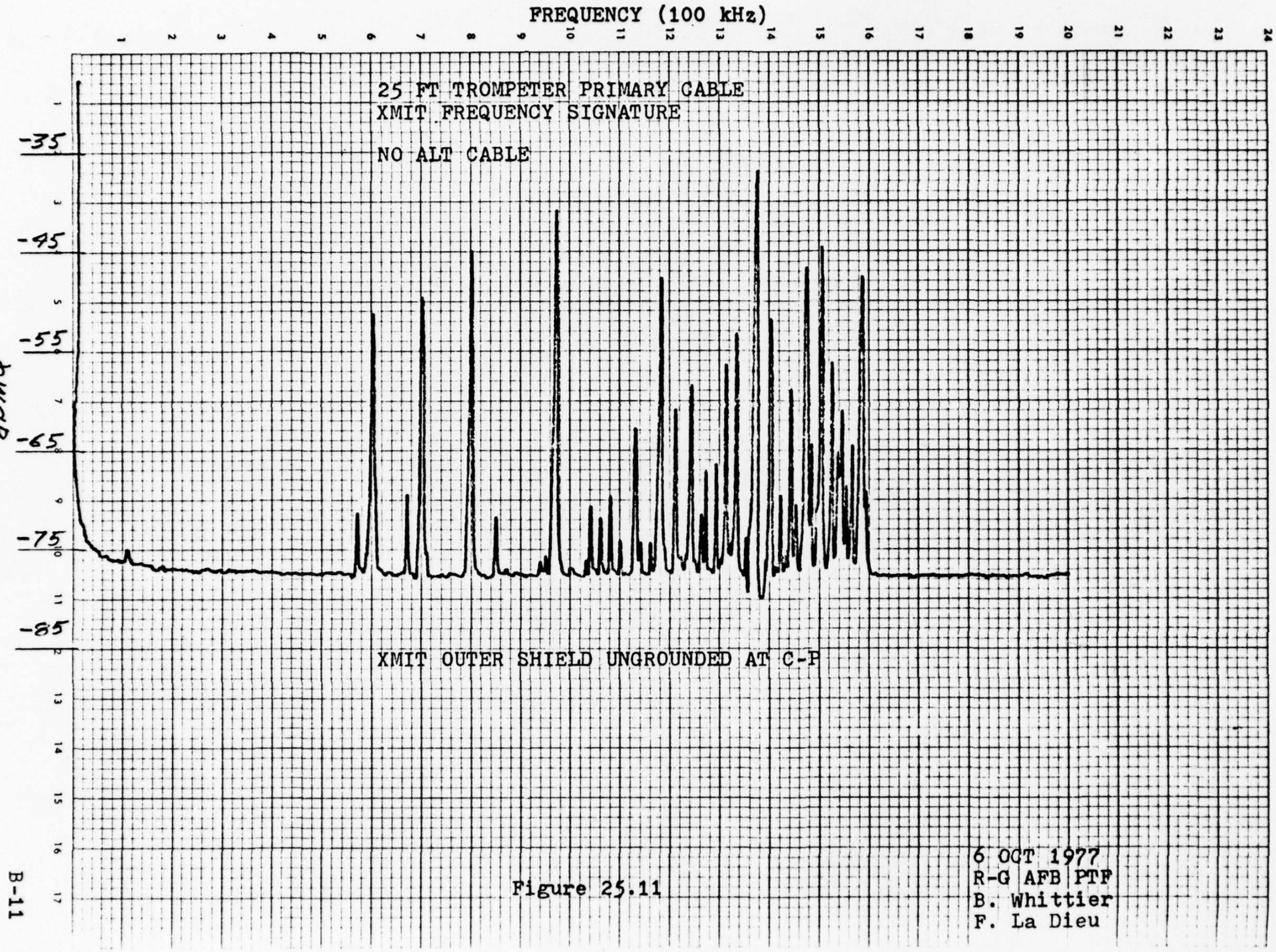

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NO ALT CABLE
XMIT OUTER SHIELD UNGROUNDED AT C-P
dBm
-35
-45
-55
-65
-75
-85
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.11

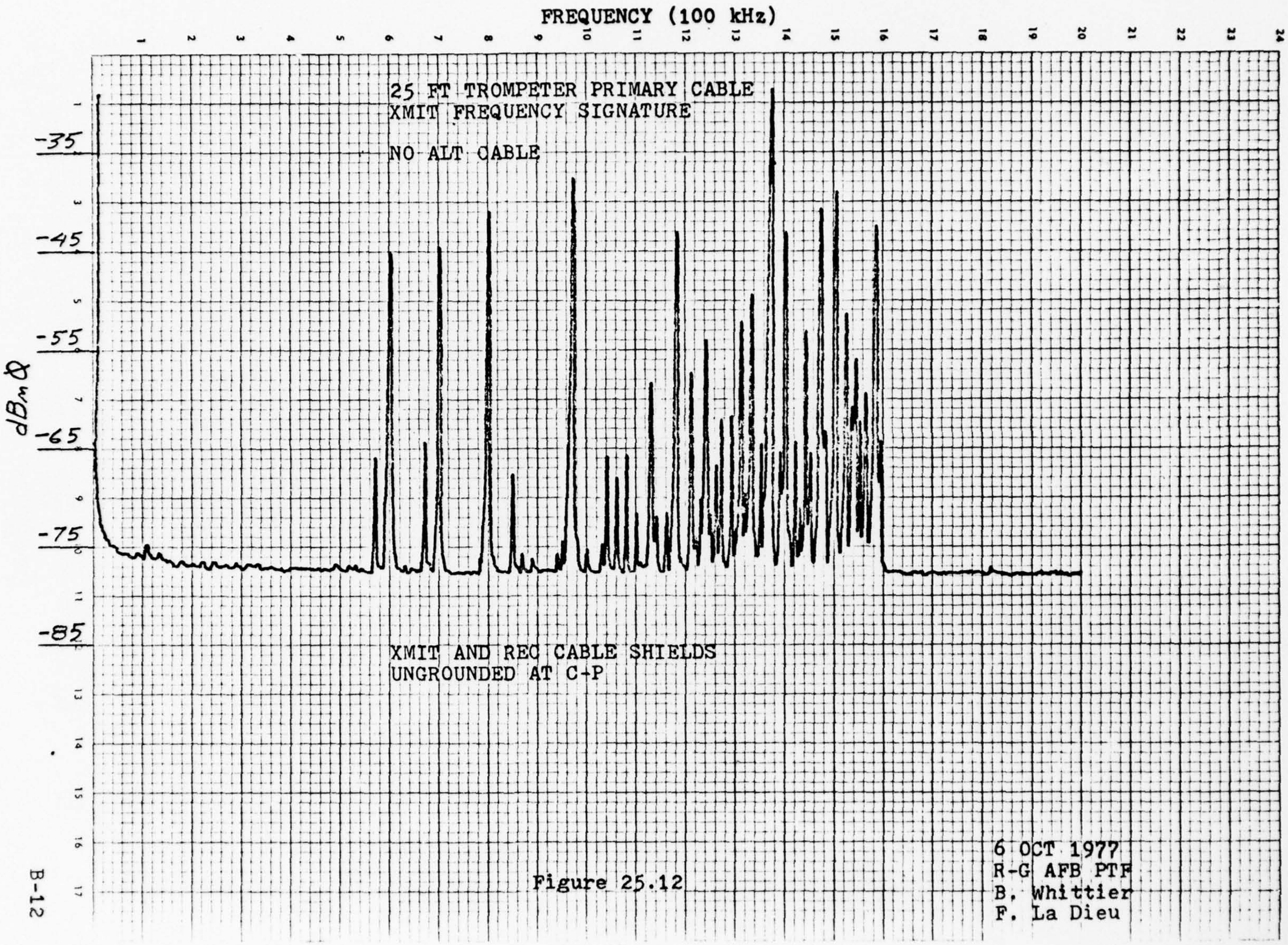

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NO ALT CABLE
XMIT AND REC CABLE SHIELDS
UNGROUNDED AT C-P
dBmØ
-35
-45
-55
-65
-75
-85
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.12

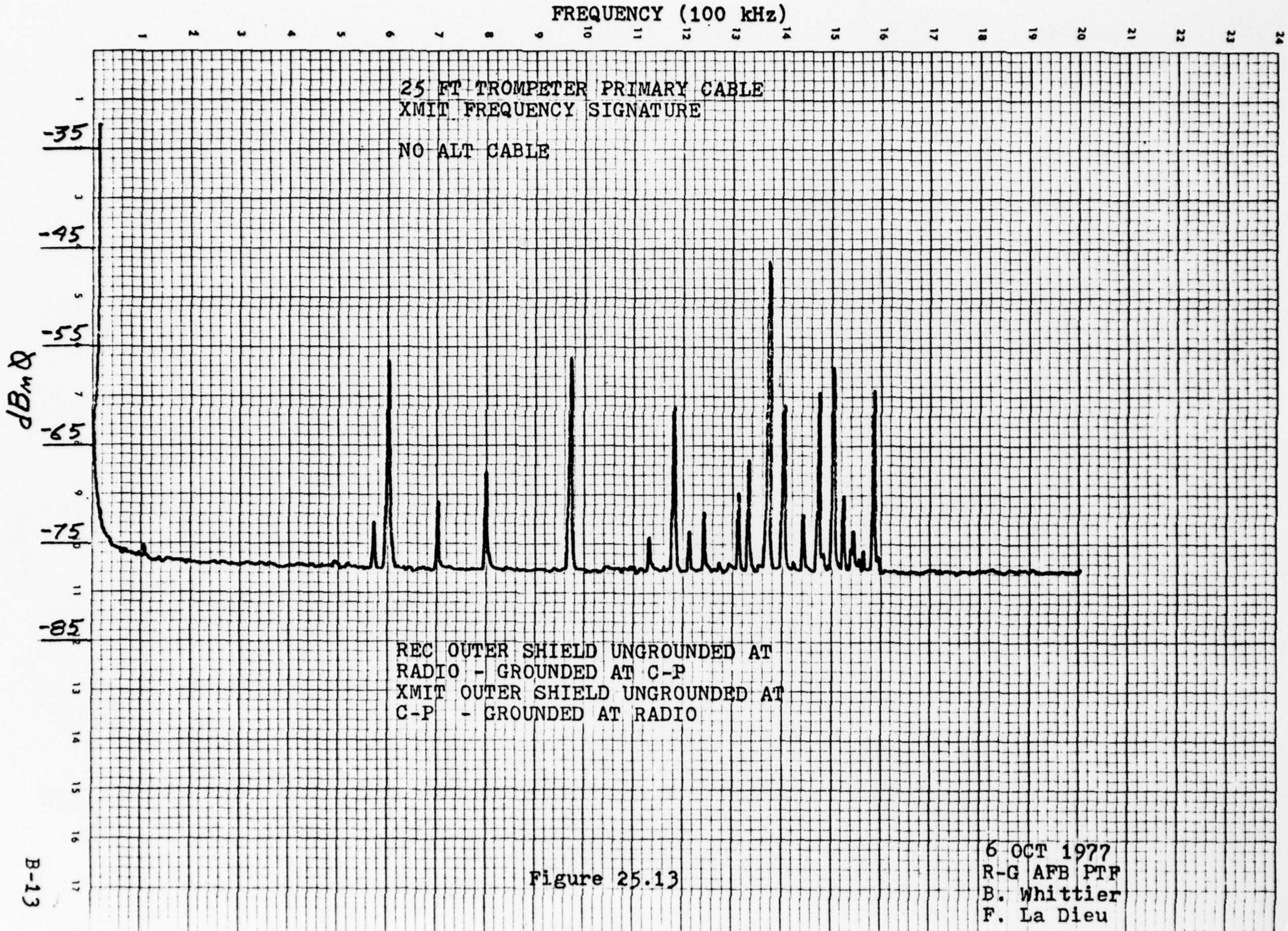

FREQUENCY (100 kHz)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
dBm
-35
-45
-55
-65
-75
-85
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NO ALT CABLE
REC OUTER SHIELD UNGROUNDED AT
RADIO - GROUNDED AT C-P
XMIT OUTER SHIELD UNGROUNDED AT
C-P - GROUNDED AT RADIO
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.13

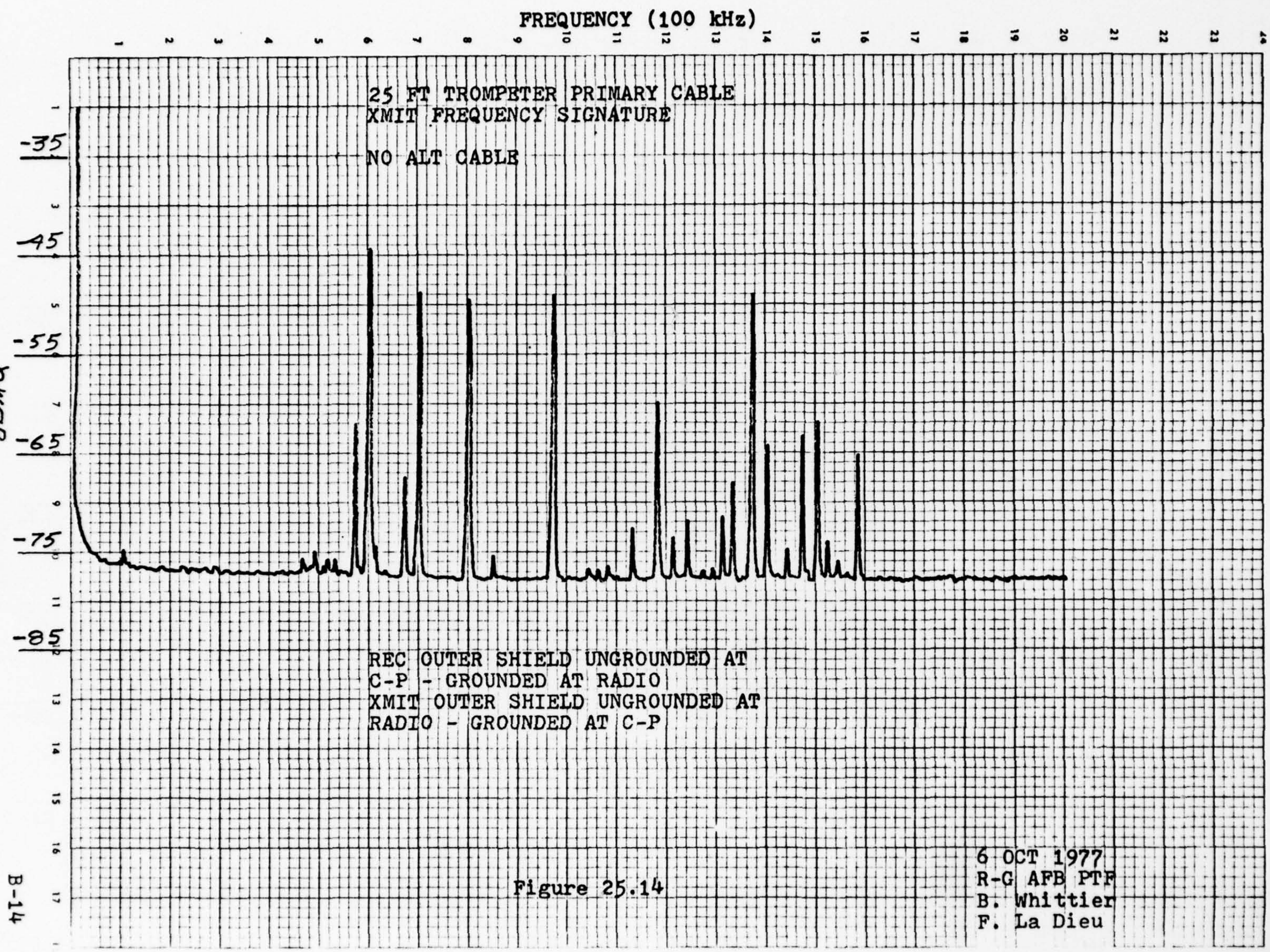

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NO ALT CABLE
dBm0
-35
-45
-55
-65
-75
-85
REC OUTER SHIELD UNGROUNDED AT
C-P - GROUNDED AT RADIO
XMIT OUTER SHIELD UNGROUNDED AT
RADIO - GROUNDED AT C-P
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.14

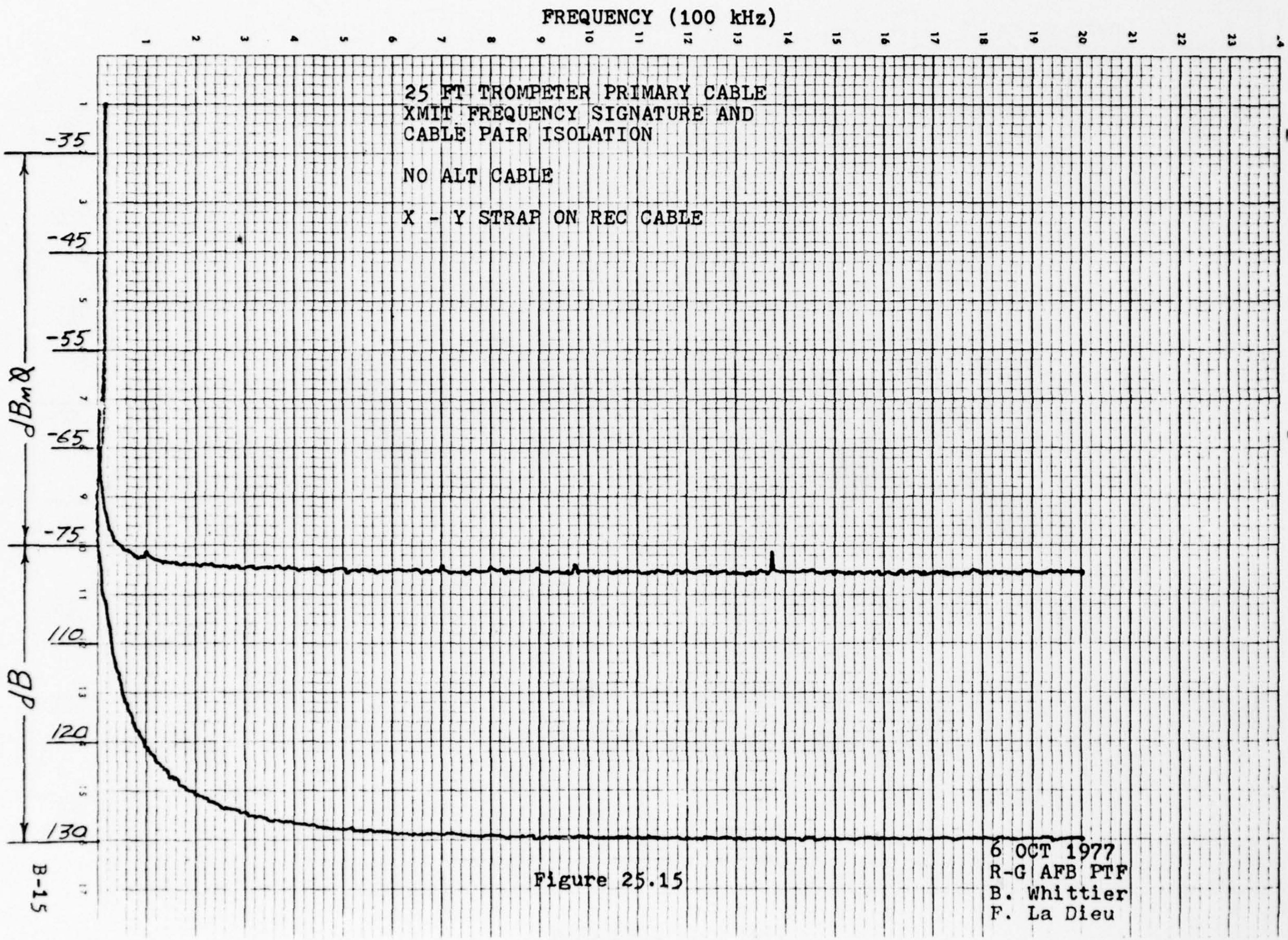
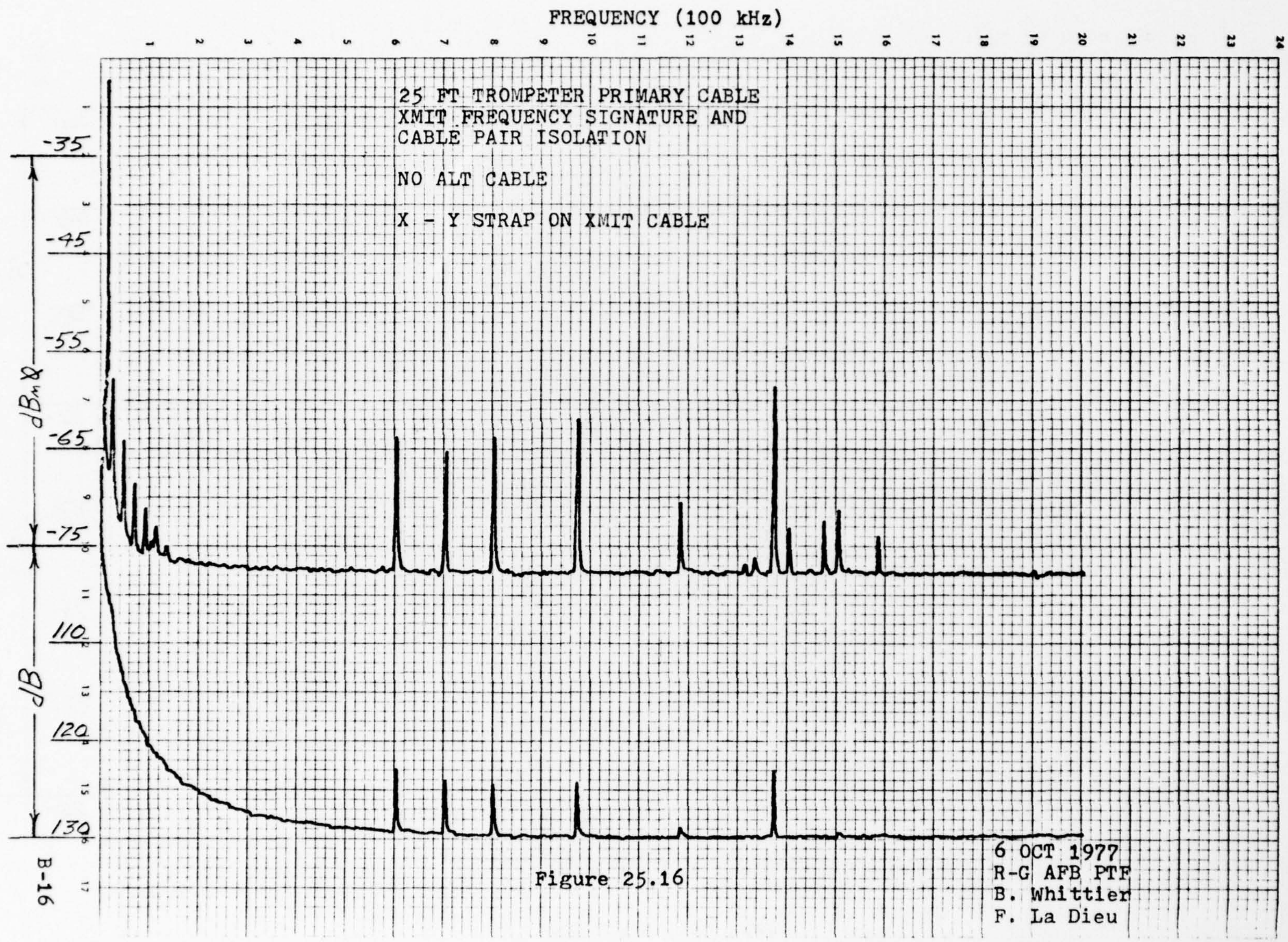
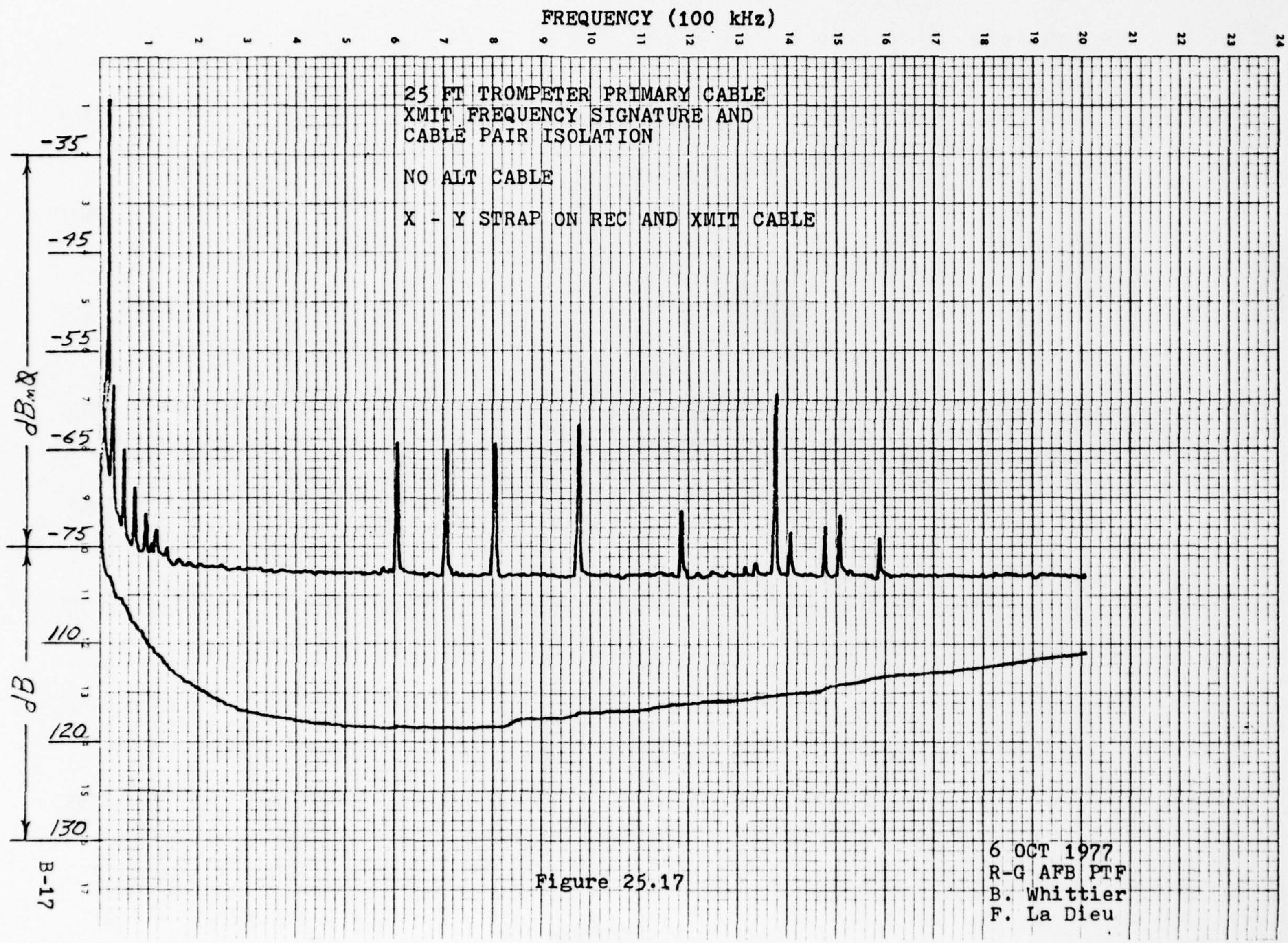

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE AND
CABLE PAIR ISOLATION
NO ALT CABLE
X - Y STRAP ON REC CABLE
-35
-45
-55
-65
-75
110
120
130
dBmQ
dB
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.15



FREQUENCY (100 kHz)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE AND
CABLE PAIR ISOLATION
NO ALT CABLE
X - Y STRAP ON XMIT CABLE
-35
-45
-55
-65
-75
110
120
130
dBm
dB
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.16



FREQUENCY (100 kHz)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE AND
CABLE PAIR ISOLATION
NO ALT CABLE
X - Y STRAP ON REC AND XMIT CABLE
-35
-45
-55
-65
-75
dBm0
110
120
130
dB
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.17

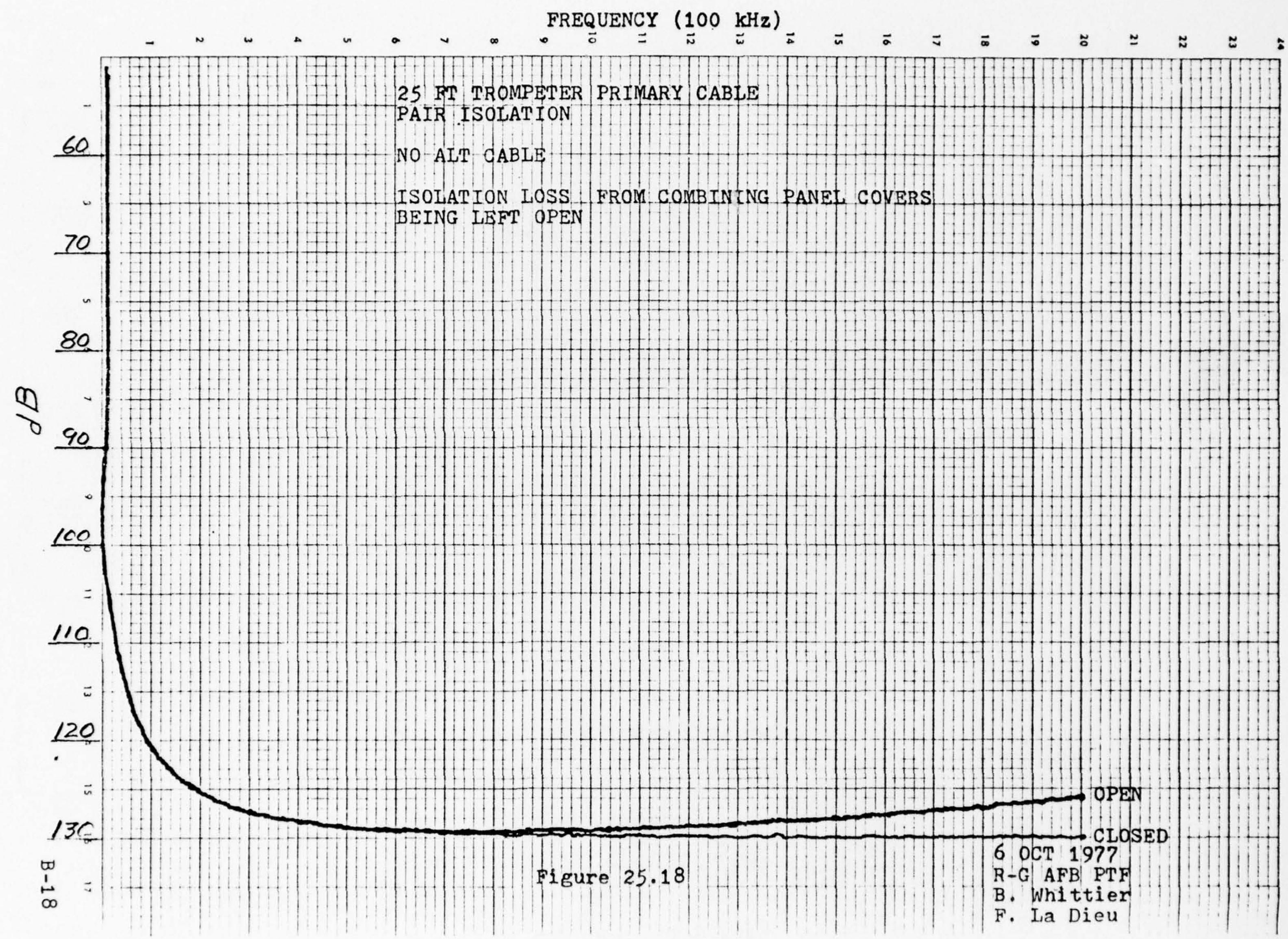

FREQUENCY (100 kHz)
25 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NO ALT CABLE
ISOLATION LOSS FROM COMBINING PANEL COVERS
BEING LEFT OPEN
dB
60
70
80
90
100
110
120
130
OPEN
CLOSED
6 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.18

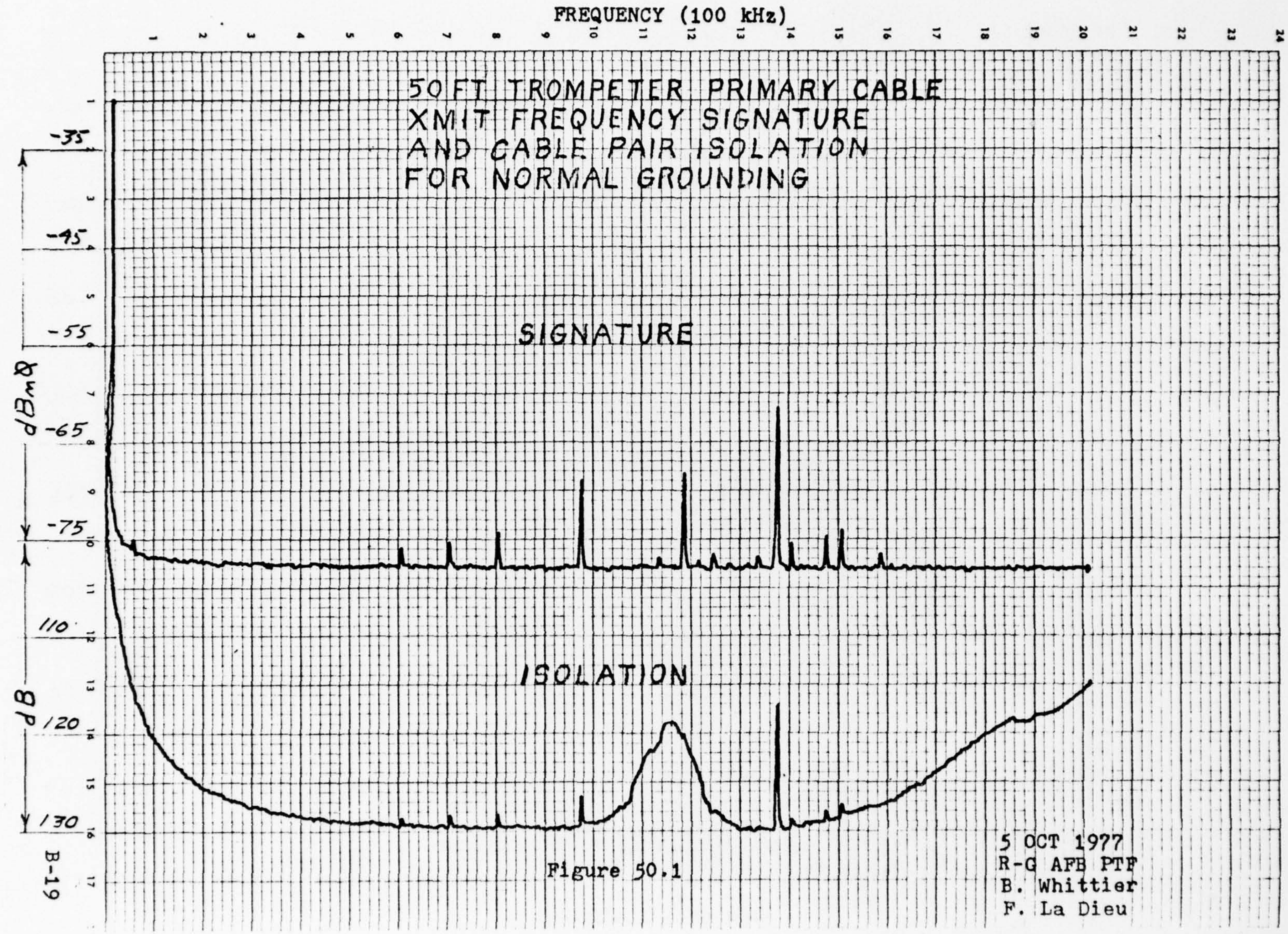

FREQUENCY (100 kHz)
50 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
AND CABLE PAIR ISOLATION
FOR NORMAL GROUNDING
SIGNATURE
ISOLATION
-35
-45
-55
-65
-75
dBm0
110
120
130
dB
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.1

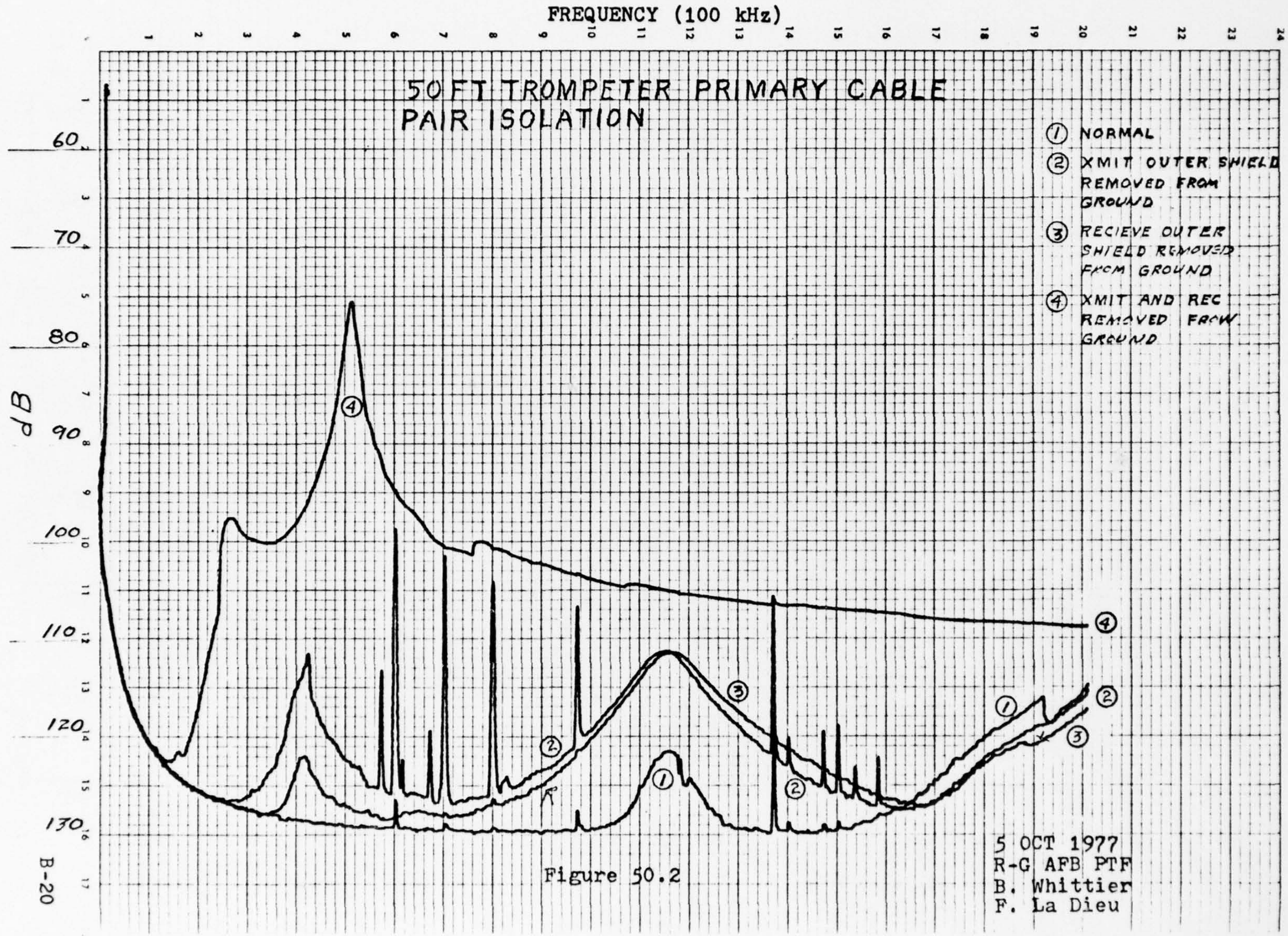

FREQUENCY (100 kHz)
50FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
1 NORMAL
2 XMIT OUTER SHIELD REMOVED FROM GROUND
3 RECIEVE OUTER SHIELD REMOVED FROM GROUND
4 XMIT AND REC REMOVED FROM GROUND
dB
60
70
80
90
100
110
120
130
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.2

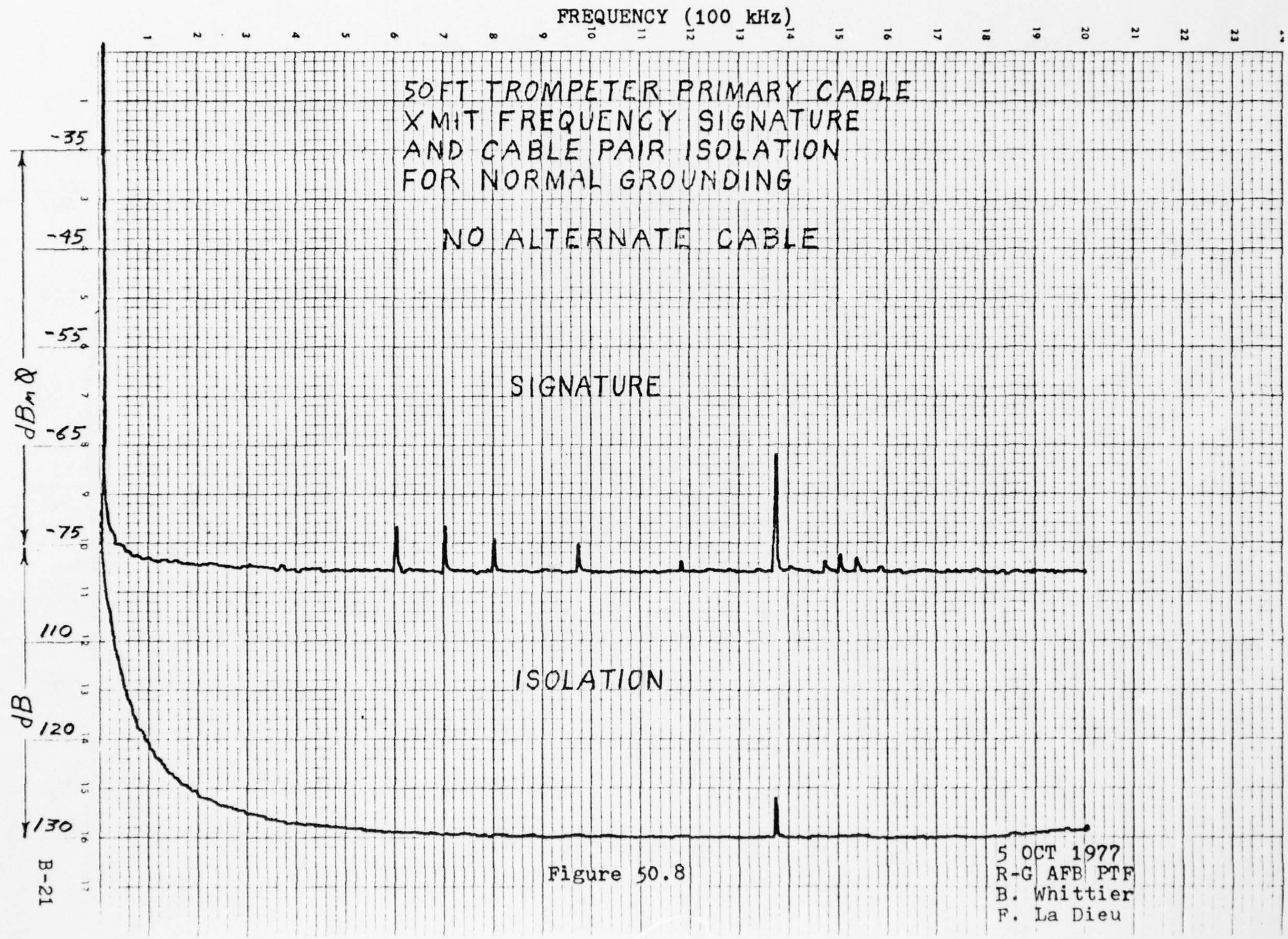

FREQUENCY (100 kHz)
50FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
AND CABLE PAIR ISOLATION
FOR NORMAL GROUNDING
NO ALTERNATE CABLE
SIGNATURE
ISOLATION
dBmØ
-35
-45
-55
-65
-75
dB
110
120
130
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.8

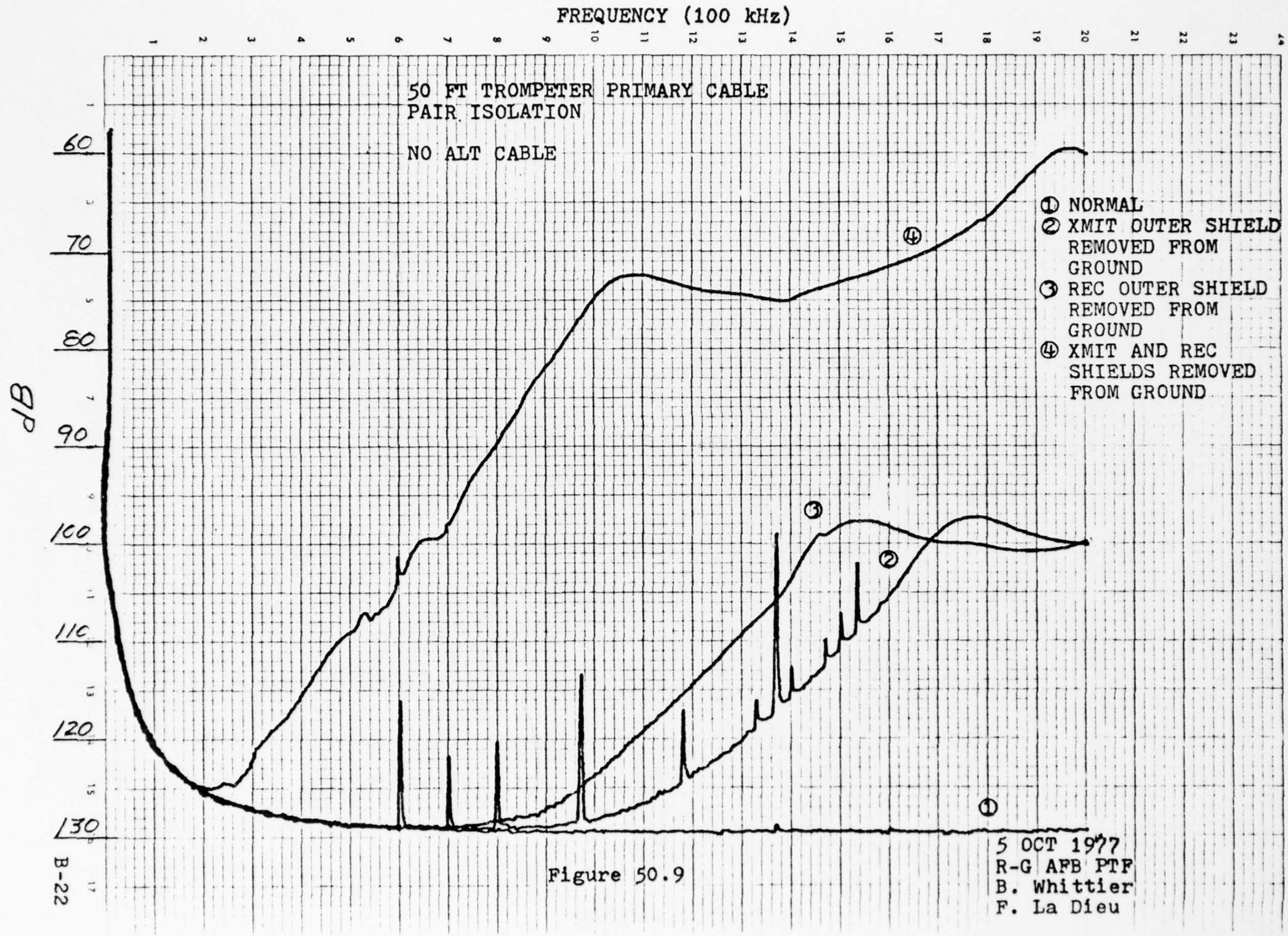

FREQUENCY (100 kHz)
50 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NO ALT CABLE
① NORMAL
② XMIT OUTER SHIELD REMOVED FROM GROUND
③ REC OUTER SHIELD REMOVED FROM GROUND
④ XMIT AND REC SHIELDS REMOVED FROM GROUND
dB
60
70
80
90
100
110
120
130
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.9

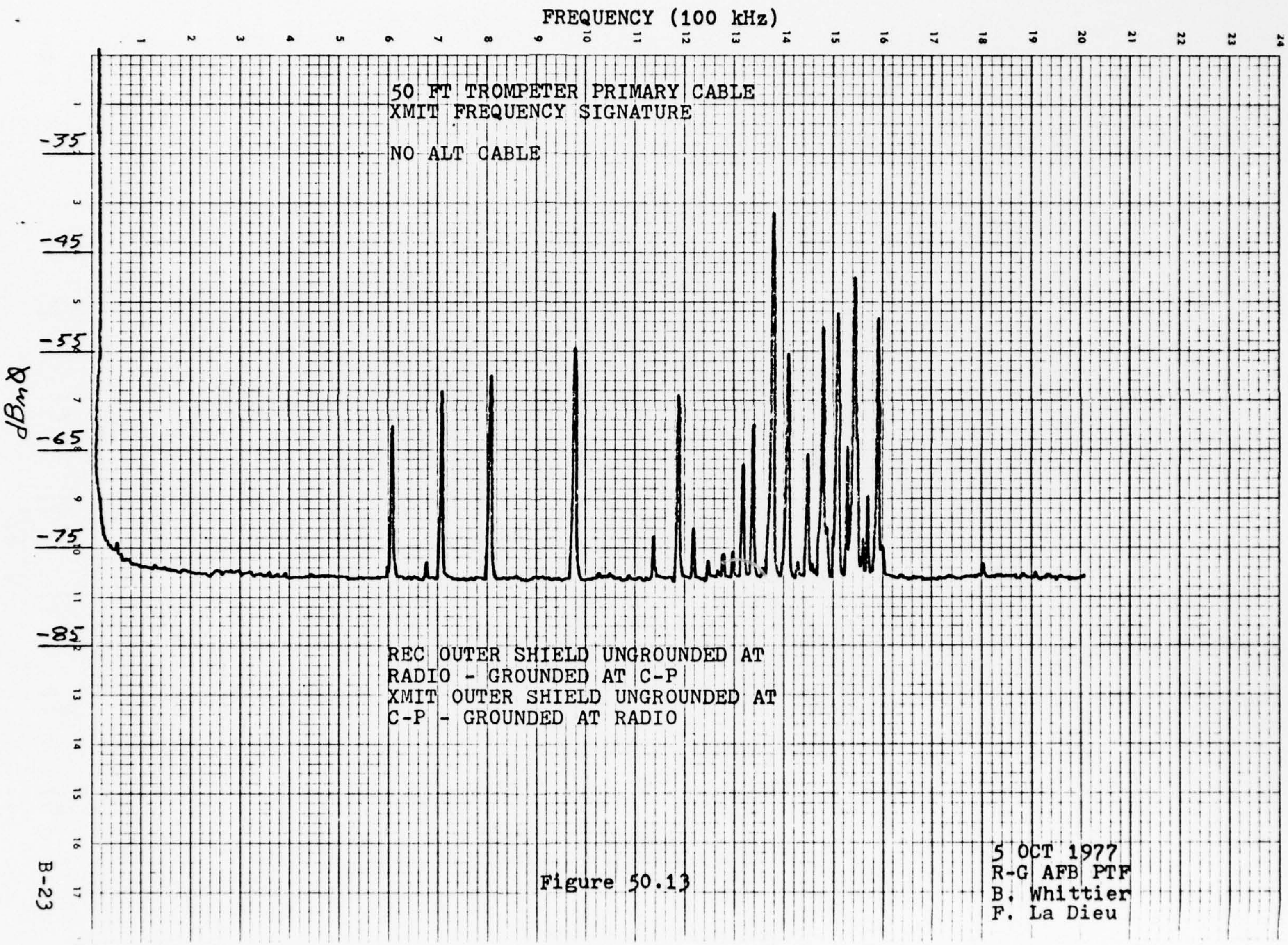
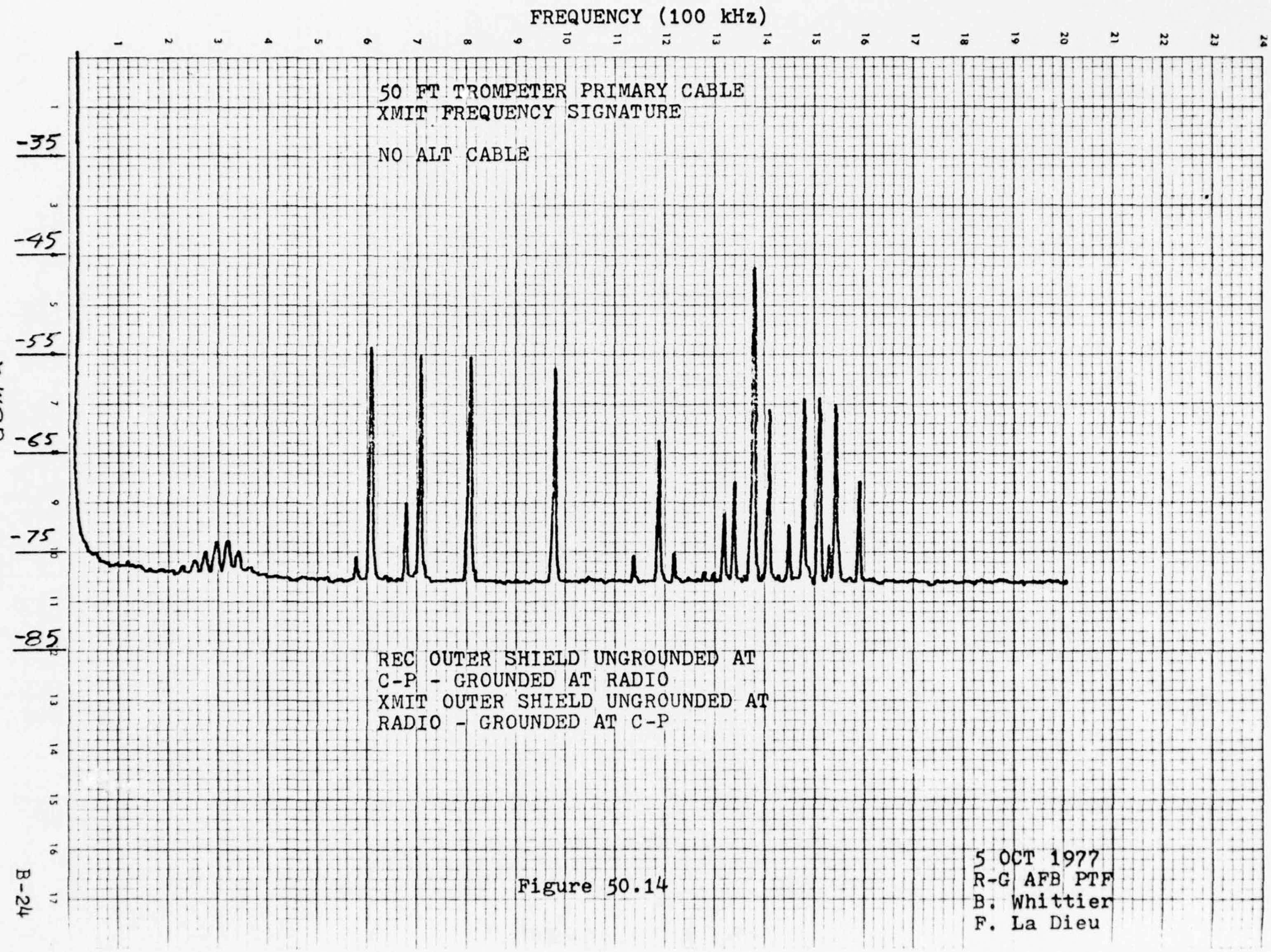
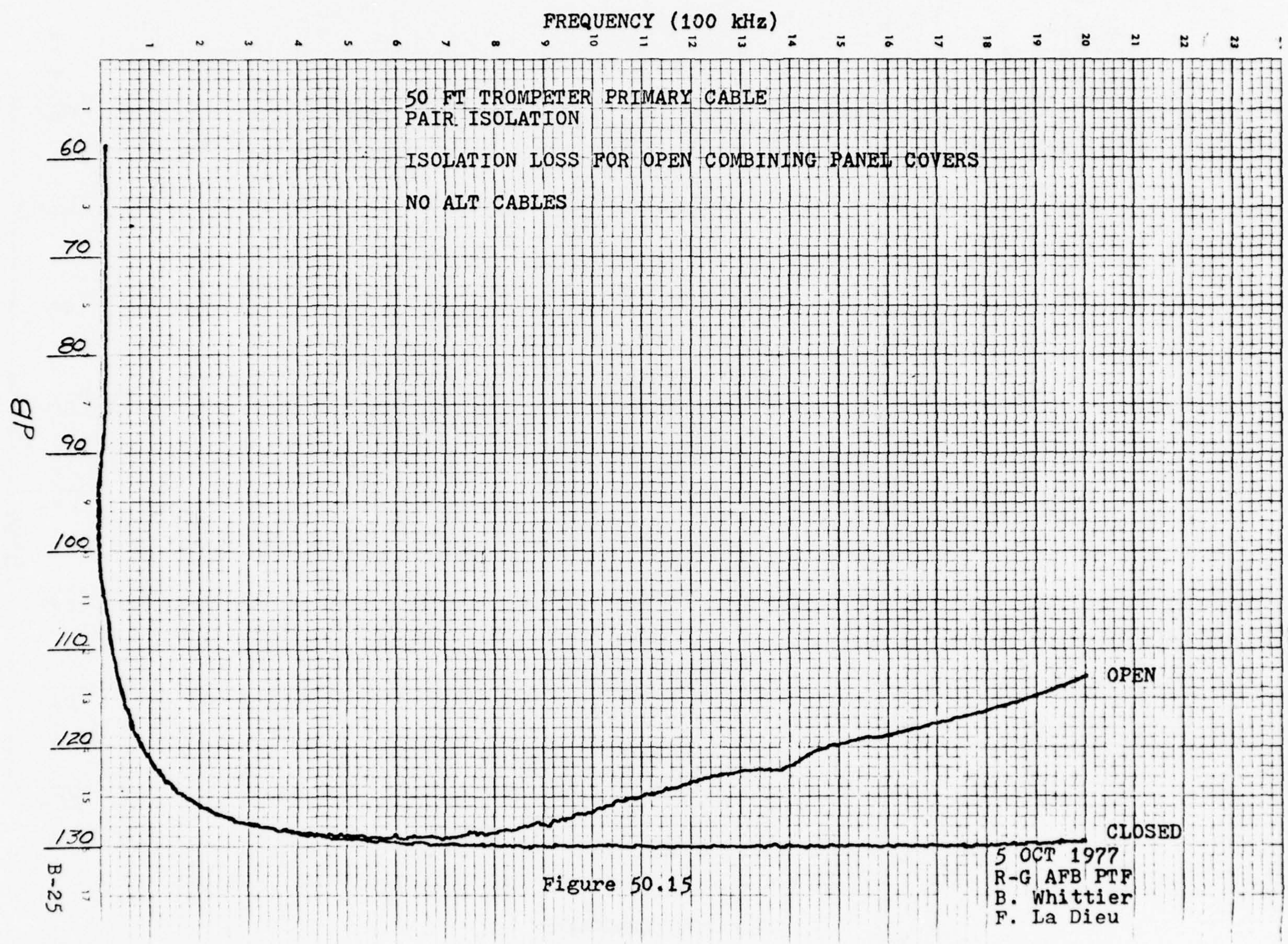

FREQUENCY (100 kHz)
50 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NO ALT CABLE
REC OUTER SHIELD UNGROUNDED AT
RADIO - GROUNDED AT C-P
XMIT OUTER SHIELD UNGROUNDED AT
C-P - GROUNDED AT RADIO
dBm
-35
-45
-55
-65
-75
-85
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.13



FREQUENCY (100 kHz)
50 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NO ALT CABLE
-35
-45
-55
-65
-75
-85
dBm Q
REC OUTER SHIELD UNGROUNDED AT
C-P - GROUNDED AT RADIO
XMIT OUTER SHIELD UNGROUNDED AT
RADIO - GROUNDED AT C-P
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.14



FREQUENCY (100 kHz)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
50 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
ISOLATION LOSS FOR OPEN COMBINING PANEL COVERS
NO ALT CABLES
dB
60
70
80
90
100
110
120
130
OPEN
CLOSED
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.15

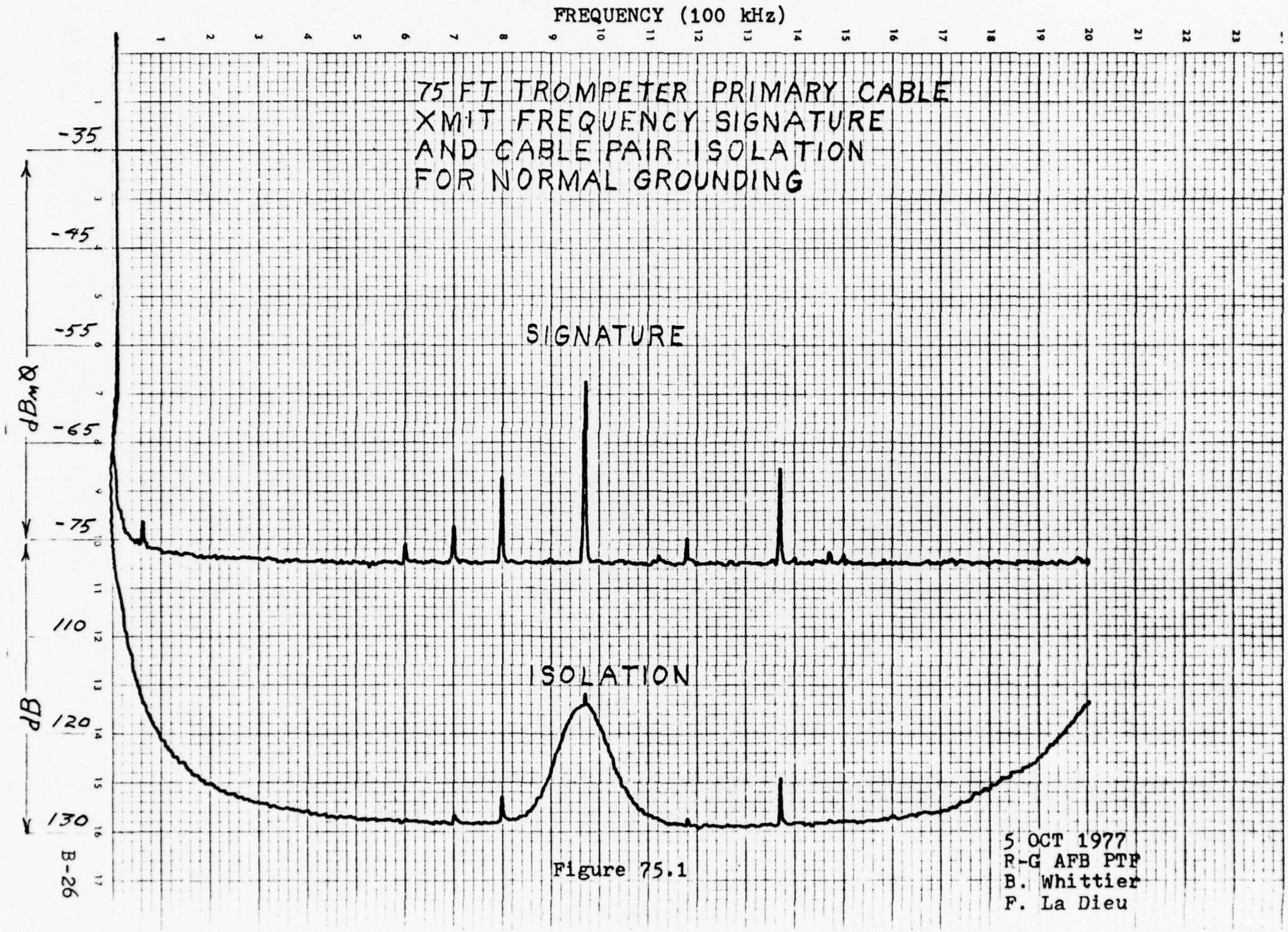

FREQUENCY (100 kHz)
75 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
AND CABLE PAIR ISOLATION
FOR NORMAL GROUNDING
SIGNATURE
ISOLATION
-35
-45
-55
-65
-75
dBmQ
110
120
130
dB
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.1

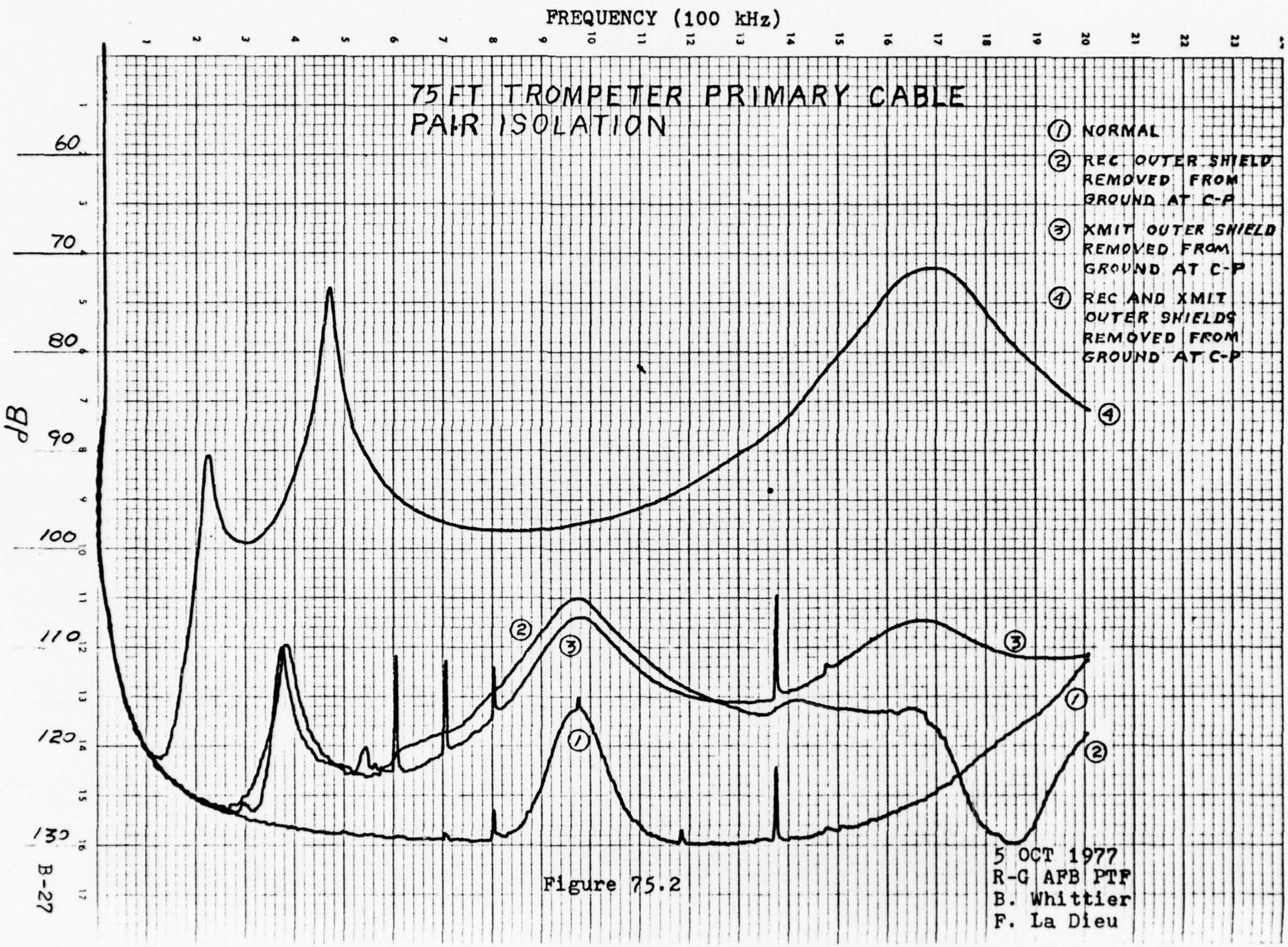

FREQUENCY (100 kHz)
75 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
1 NORMAL
2 REC OUTER SHIELD REMOVED FROM GROUND AT C-P
3 XMIT OUTER SHIELD REMOVED FROM GROUND AT C-P
4 REC AND XMIT OUTER SHIELDS REMOVED FROM GROUND AT C-P
dB
60
70
80
90
100
110
120
130
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.2

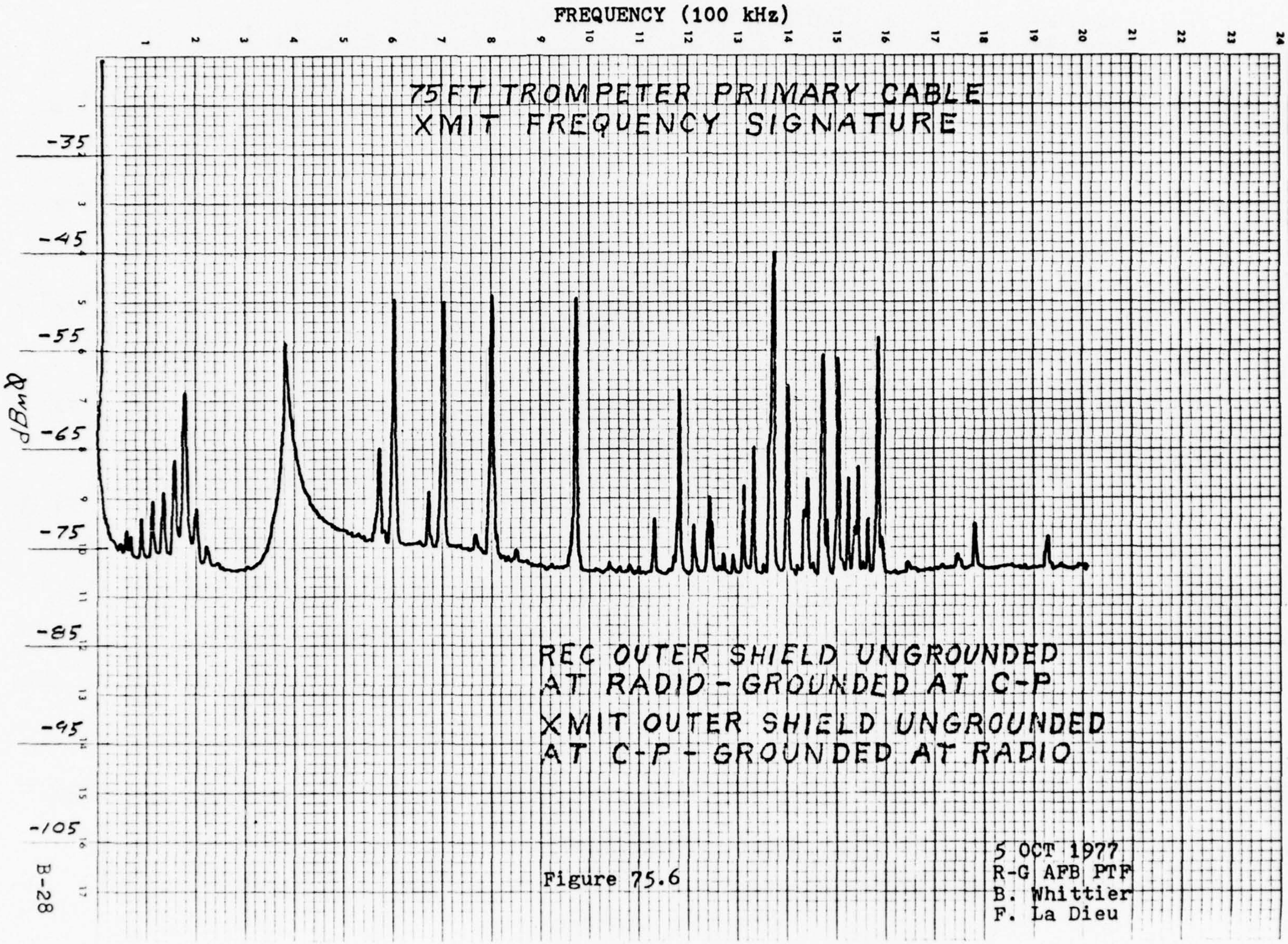

FREQUENCY (100 kHz)
75FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
dBm
-35
-45
-55
-65
-75
-85
-95
-105
REC OUTER SHIELD UNGROUNDED
AT RADIO - GROUNDED AT C-P
XMIT OUTER SHIELD UNGROUNDED
AT C-P - GROUNDED AT RADIO
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.6

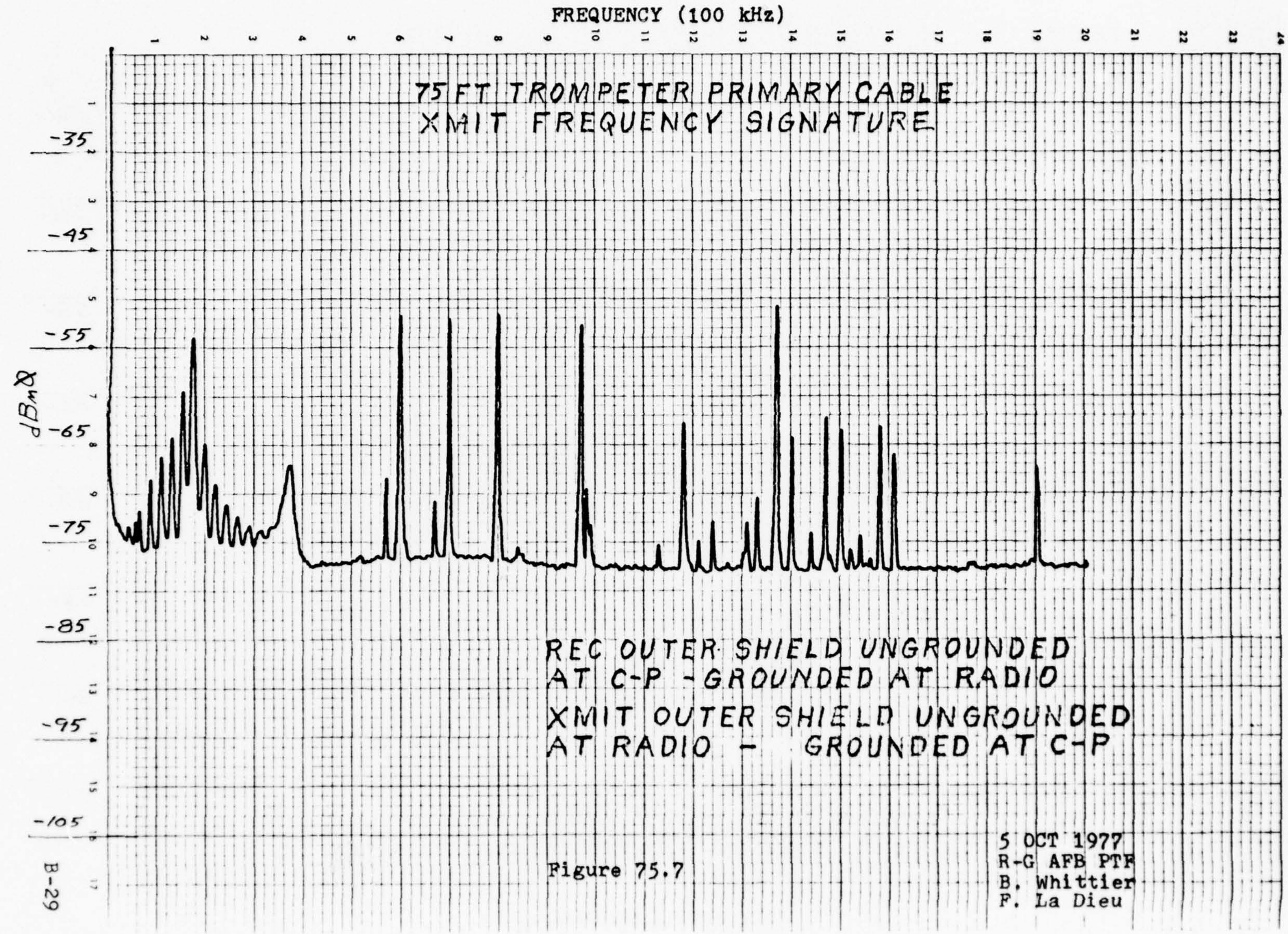

FREQUENCY (100 kHz)
75 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
REC OUTER SHIELD UNGROUNDED
AT C-P - GROUNDED AT RADIO
XMIT OUTER SHIELD UNGROUNDED
AT RADIO - GROUNDED AT C-P
dBmΦ
-35
-45
-55
-65
-75
-85
-95
-105
5 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.7

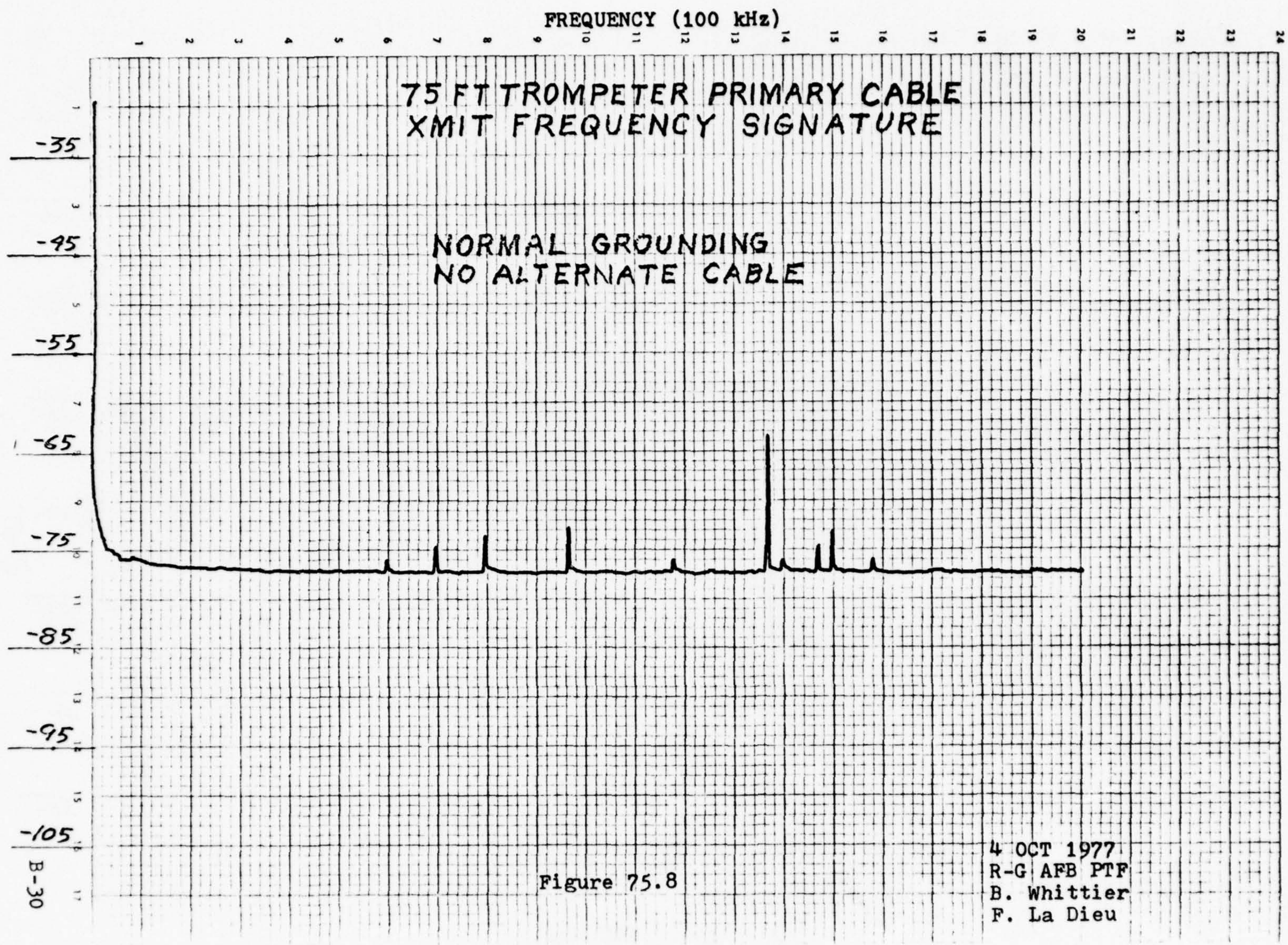

FREQUENCY (100 kHz)
75 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NORMAL GROUNDING
NO ALTERNATE CABLE
-35
-95
-55
-65
-75
-85
-95
-105
4 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.8

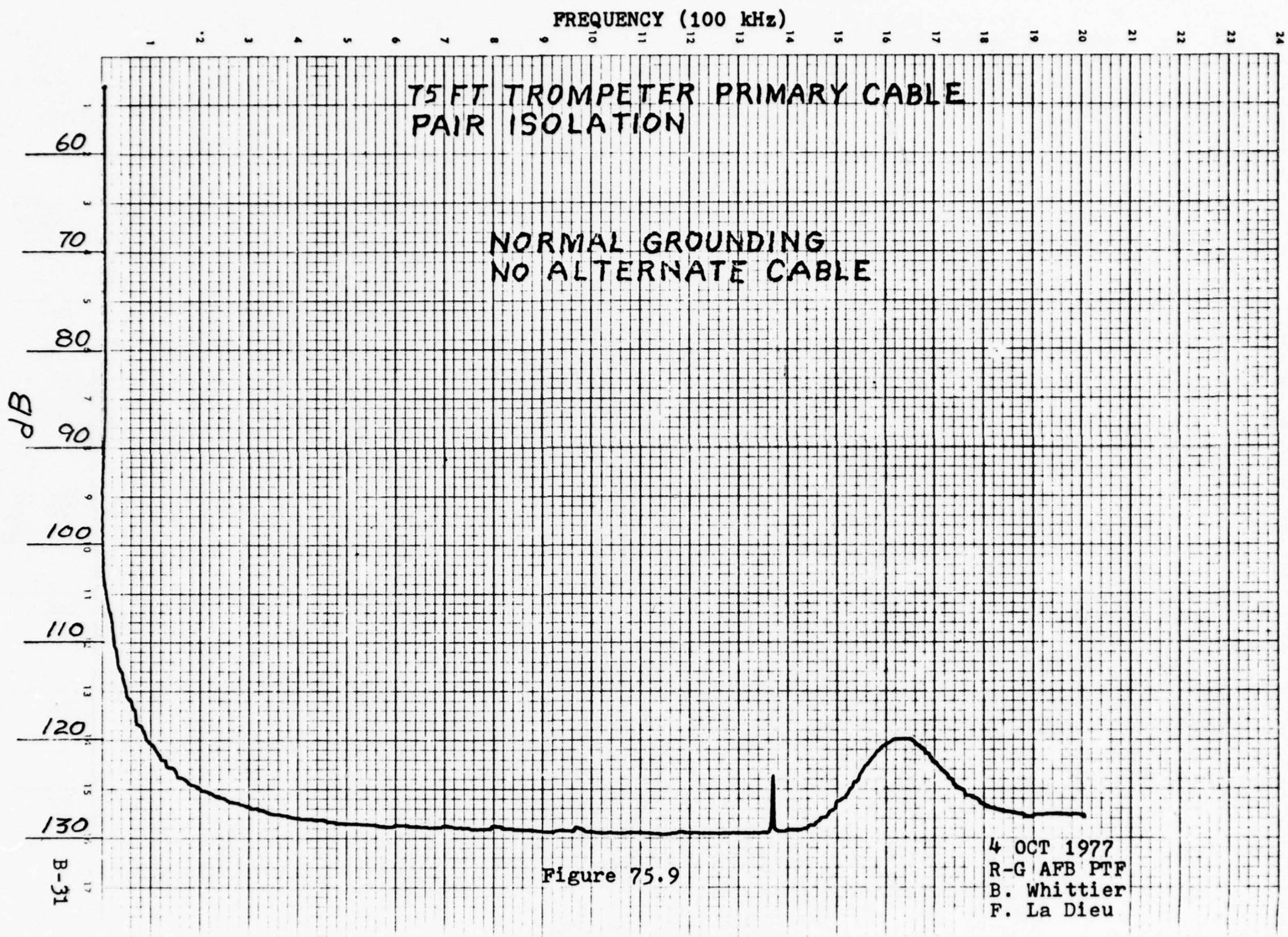

FREQUENCY (100 kHz)
75 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NORMAL GROUNDING
NO ALTERNATE CABLE
dB
60
70
80
90
100
110
120
130
4 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.9

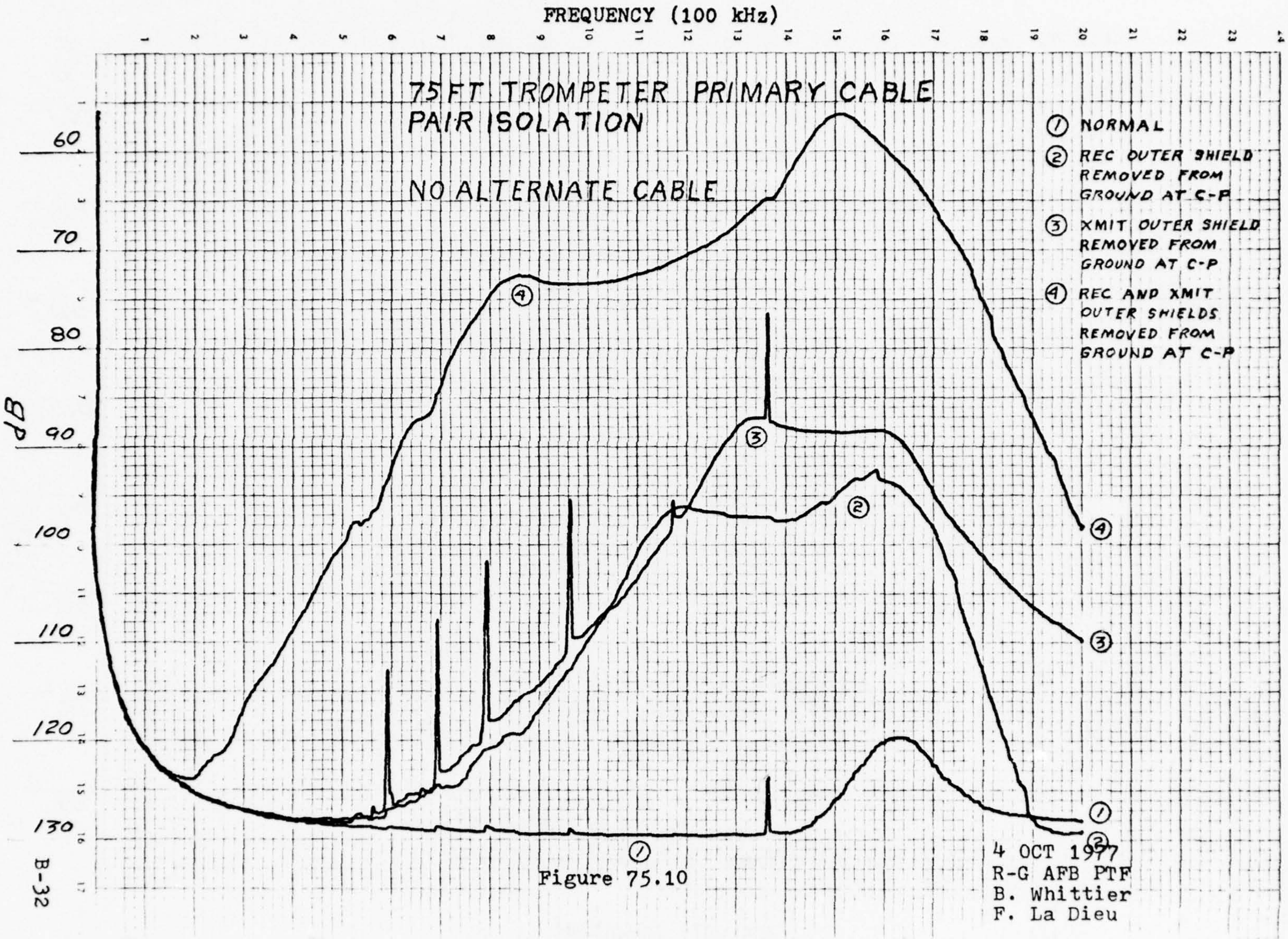

FREQUENCY (100 kHz)
75 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NO ALTERNATE CABLE
dB
60
70
80
90
100
110
120
130
1 NORMAL
2 REC OUTER SHIELD REMOVED FROM GROUND AT C-P
3 XMIT OUTER SHIELD REMOVED FROM GROUND AT C-P
4 REC AND XMIT OUTER SHIELDS REMOVED FROM GROUND AT C-P
4 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.10

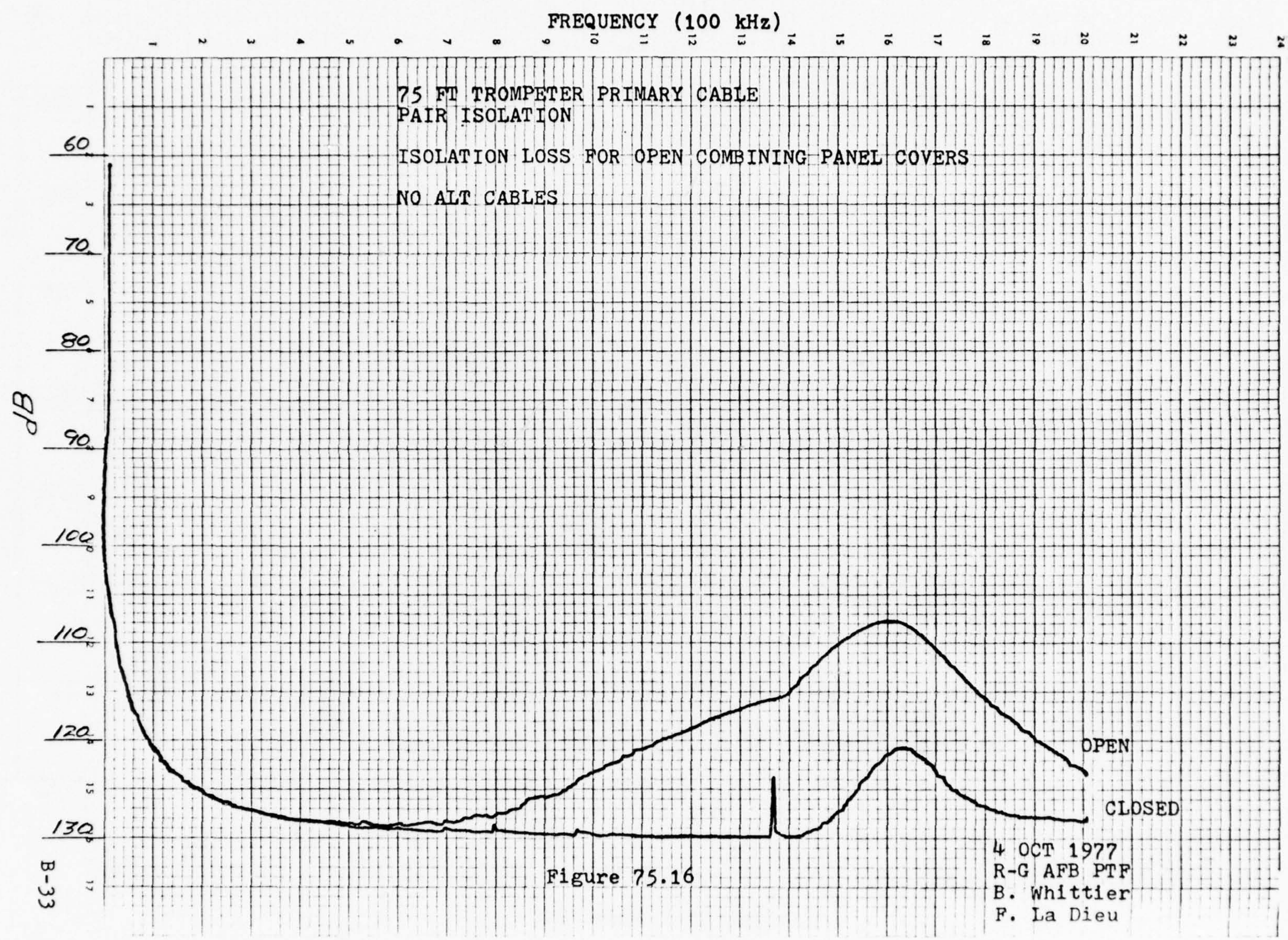

FREQUENCY (100 kHz)
75 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
ISOLATION LOSS FOR OPEN COMBINING PANEL COVERS
NO ALT CABLES
dB
60
70
80
90
100
110
120
130
OPEN
CLOSED
4 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.16

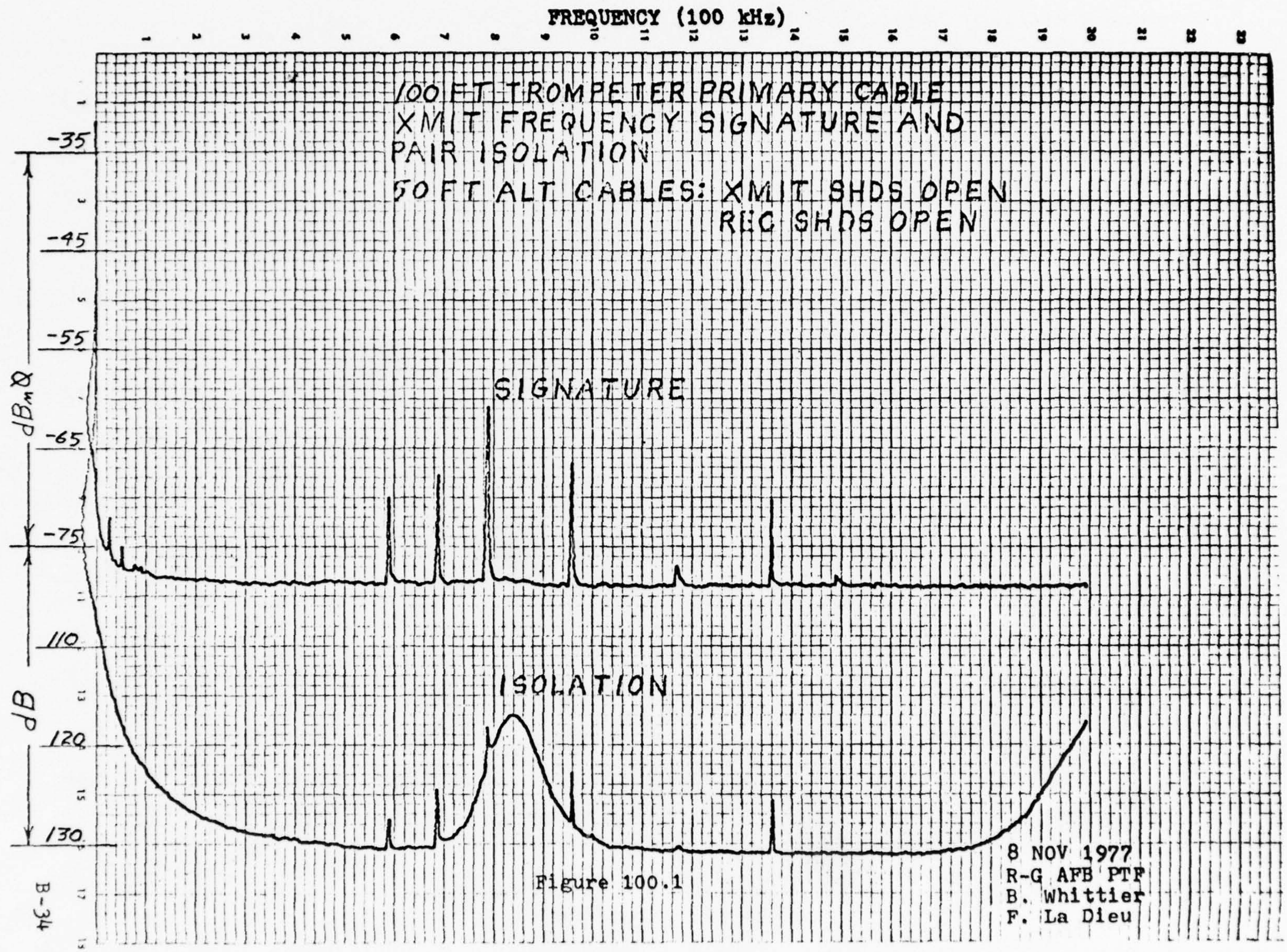

FREQUENCY (100 kHz)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
100 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE AND
PAIR ISOLATION
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
SIGNATURE
ISOLATION
-35
-45
-55
-65
-75
110
120
130
dBmØ
dB
8 NOV 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 100.1

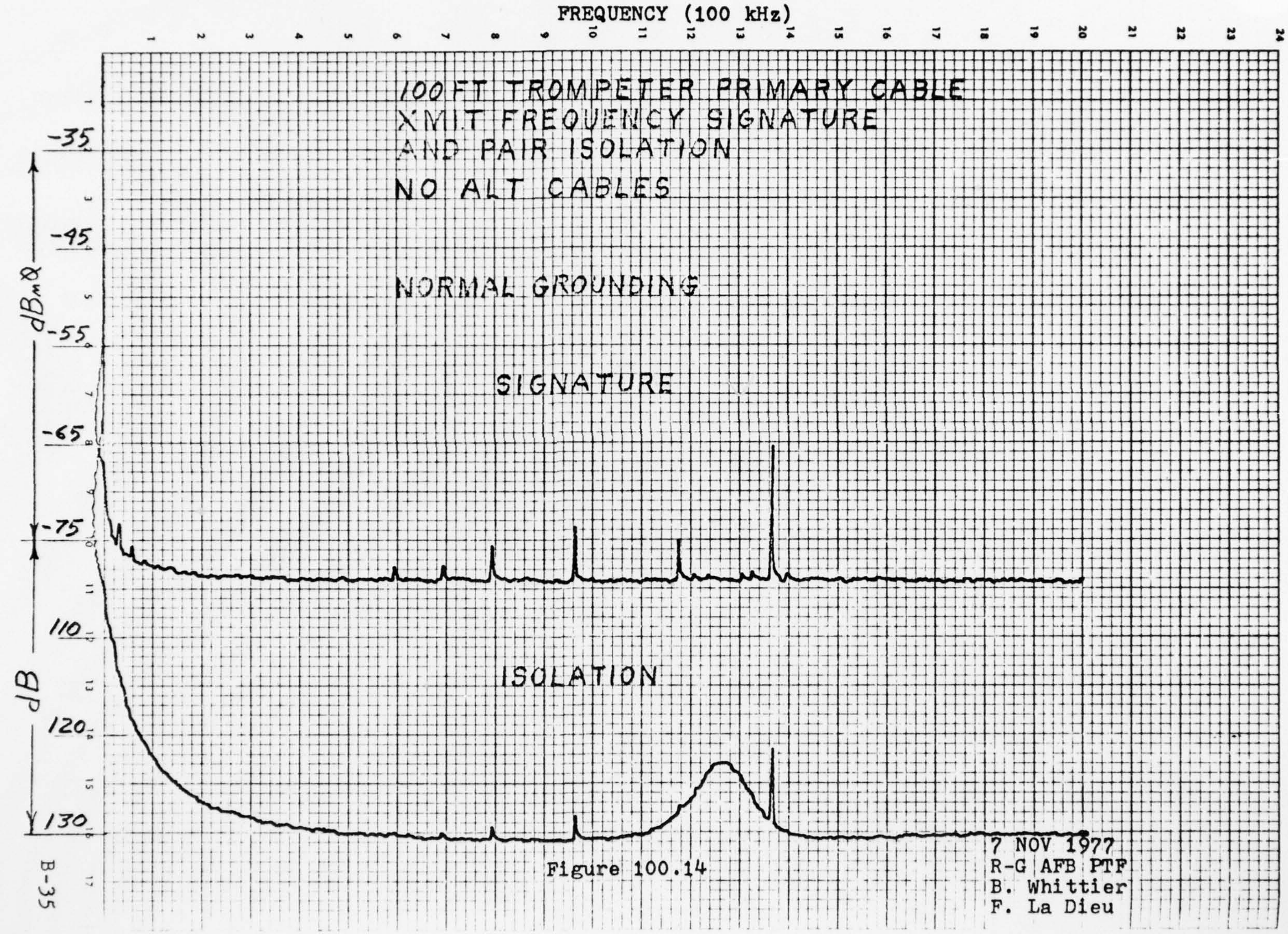


Figure 100.14

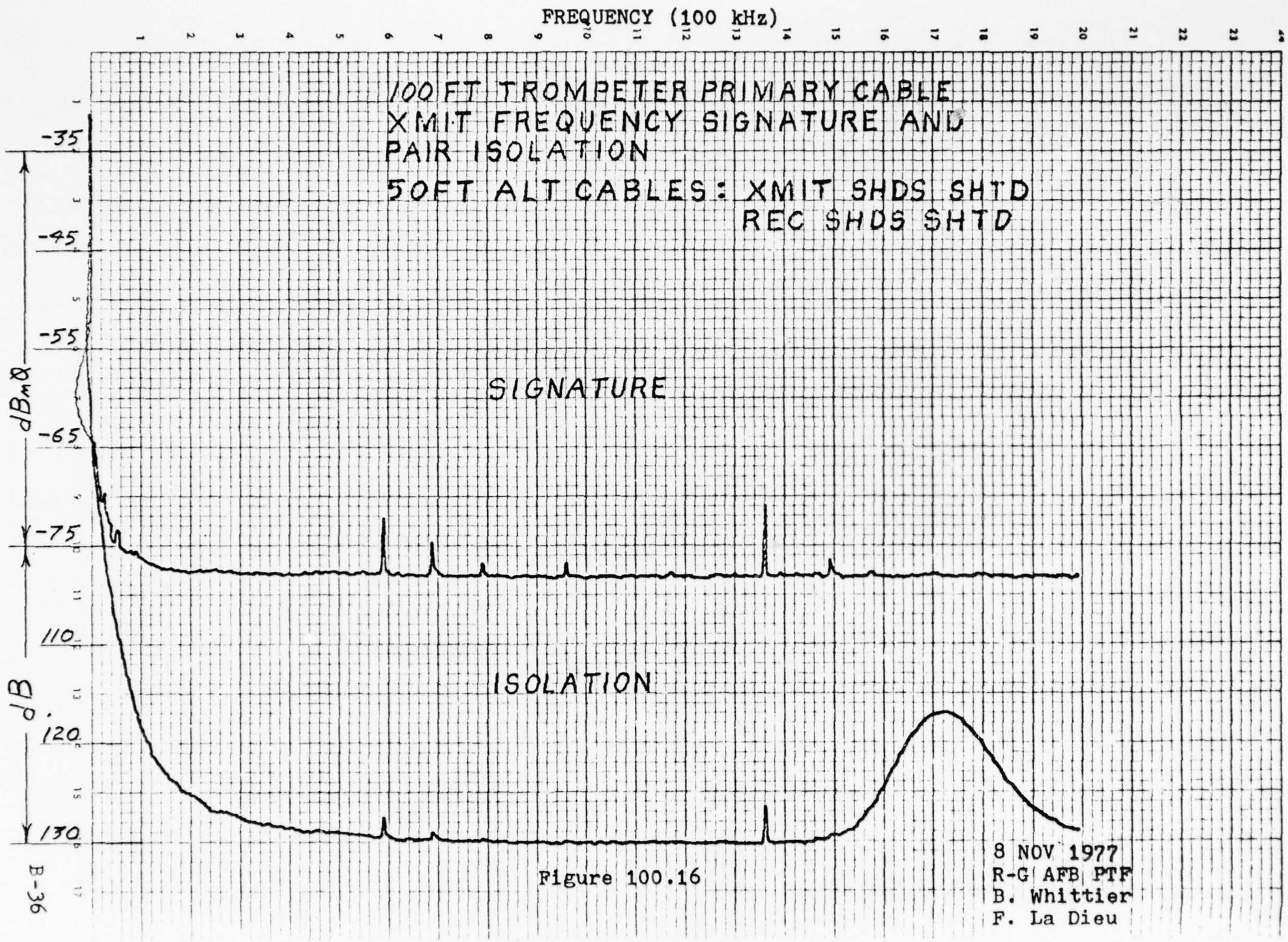


Figure 100.16

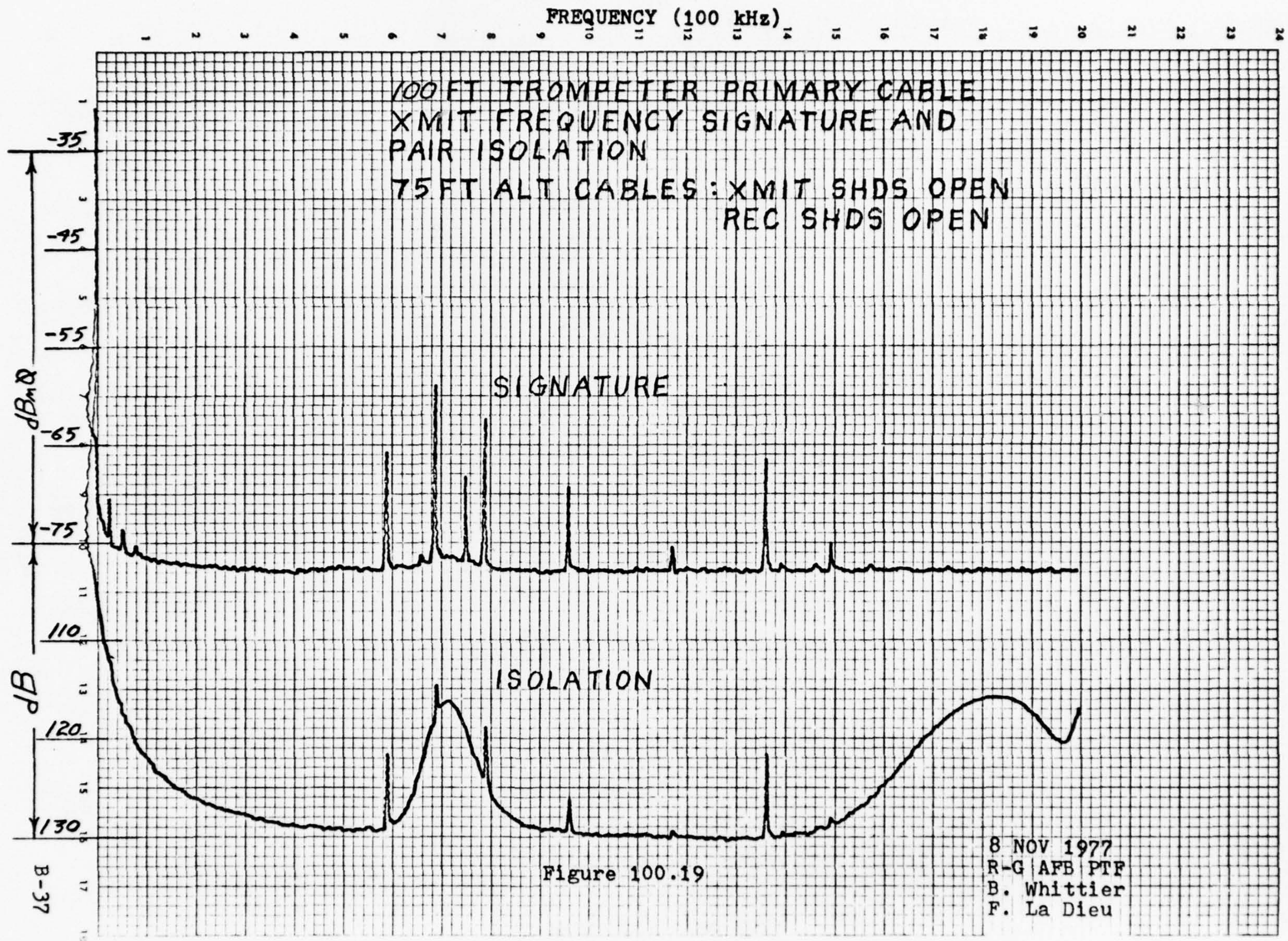


Figure 100.19

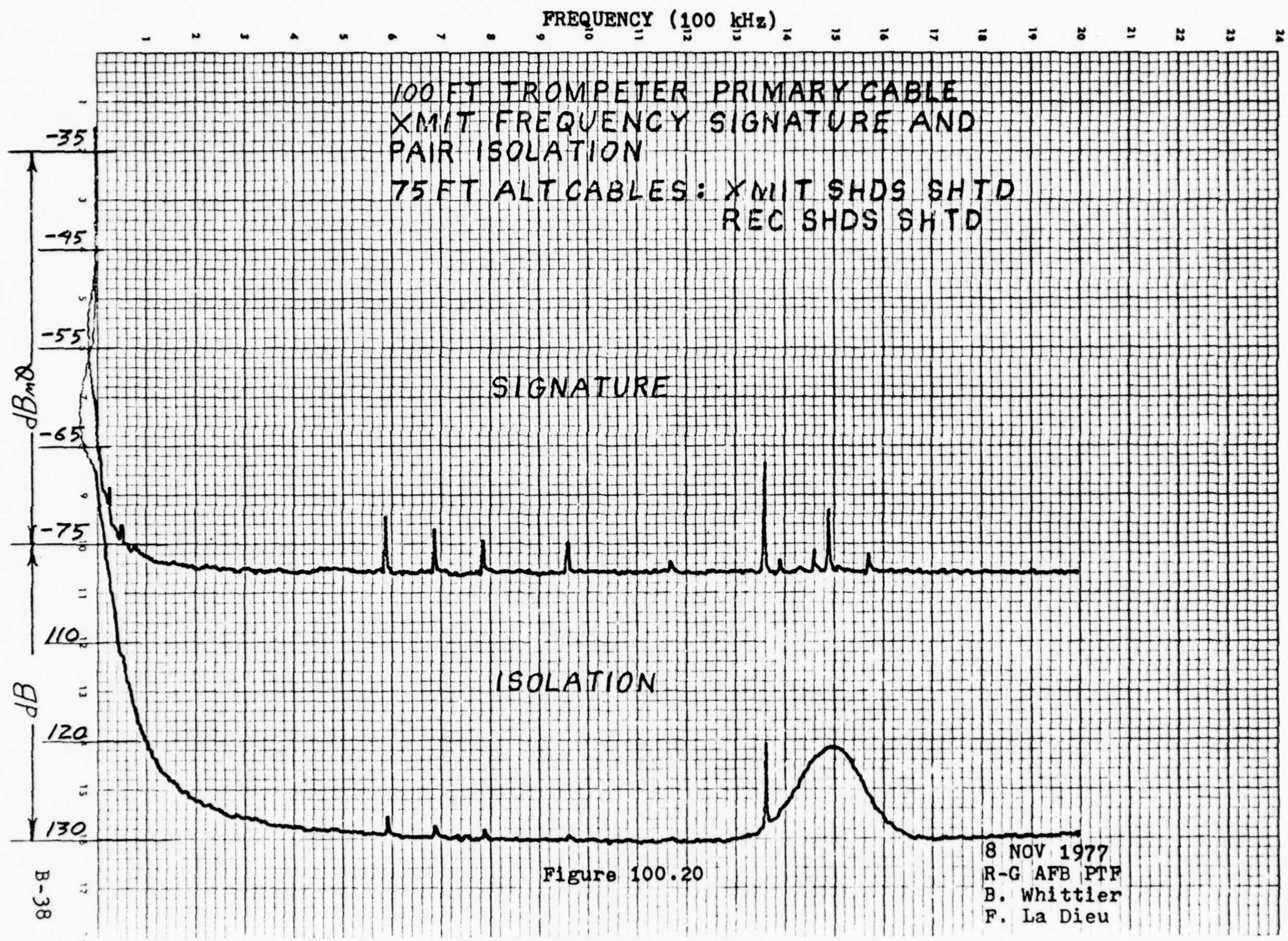


Figure 100.20

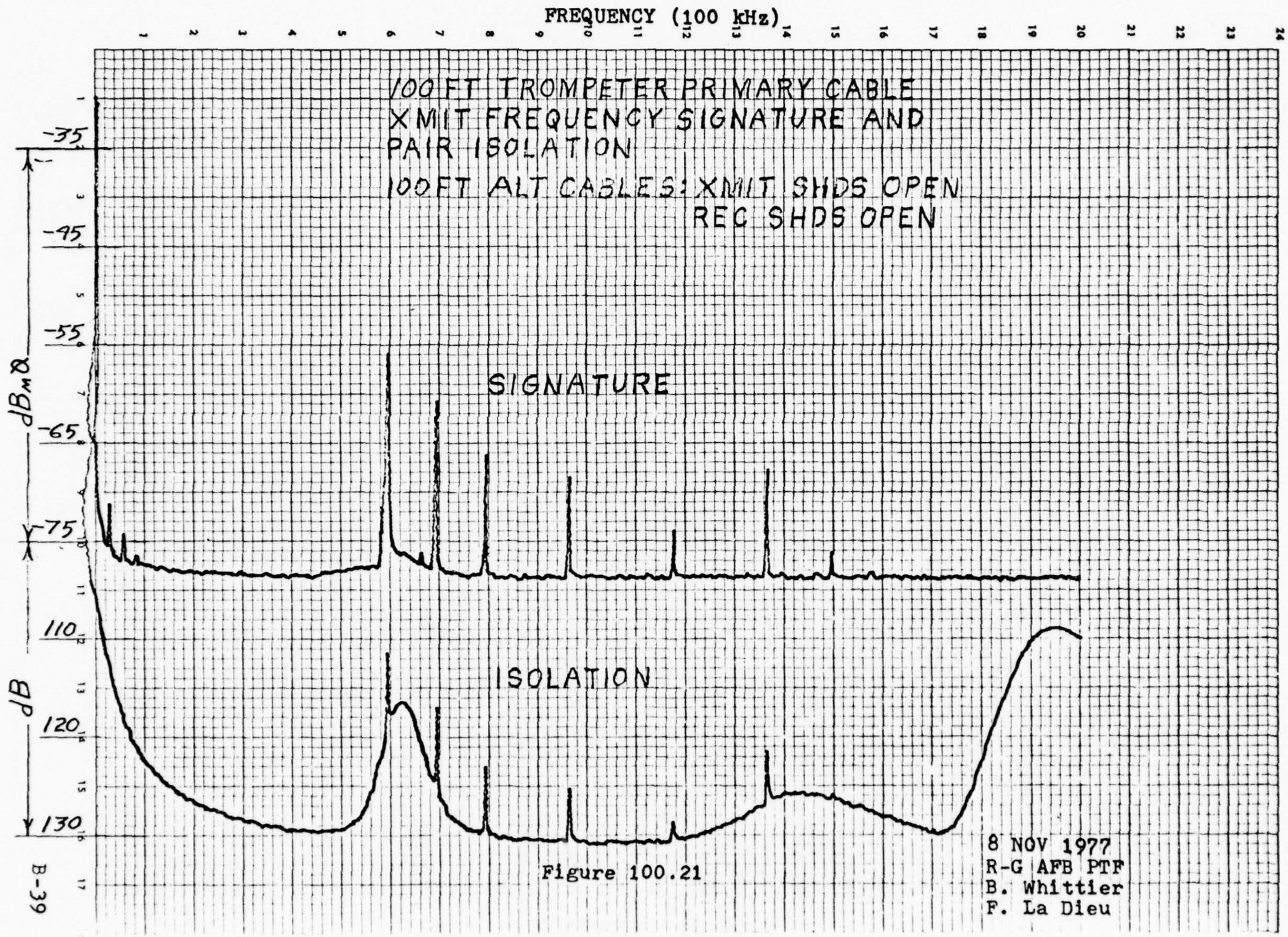


Figure 100.21

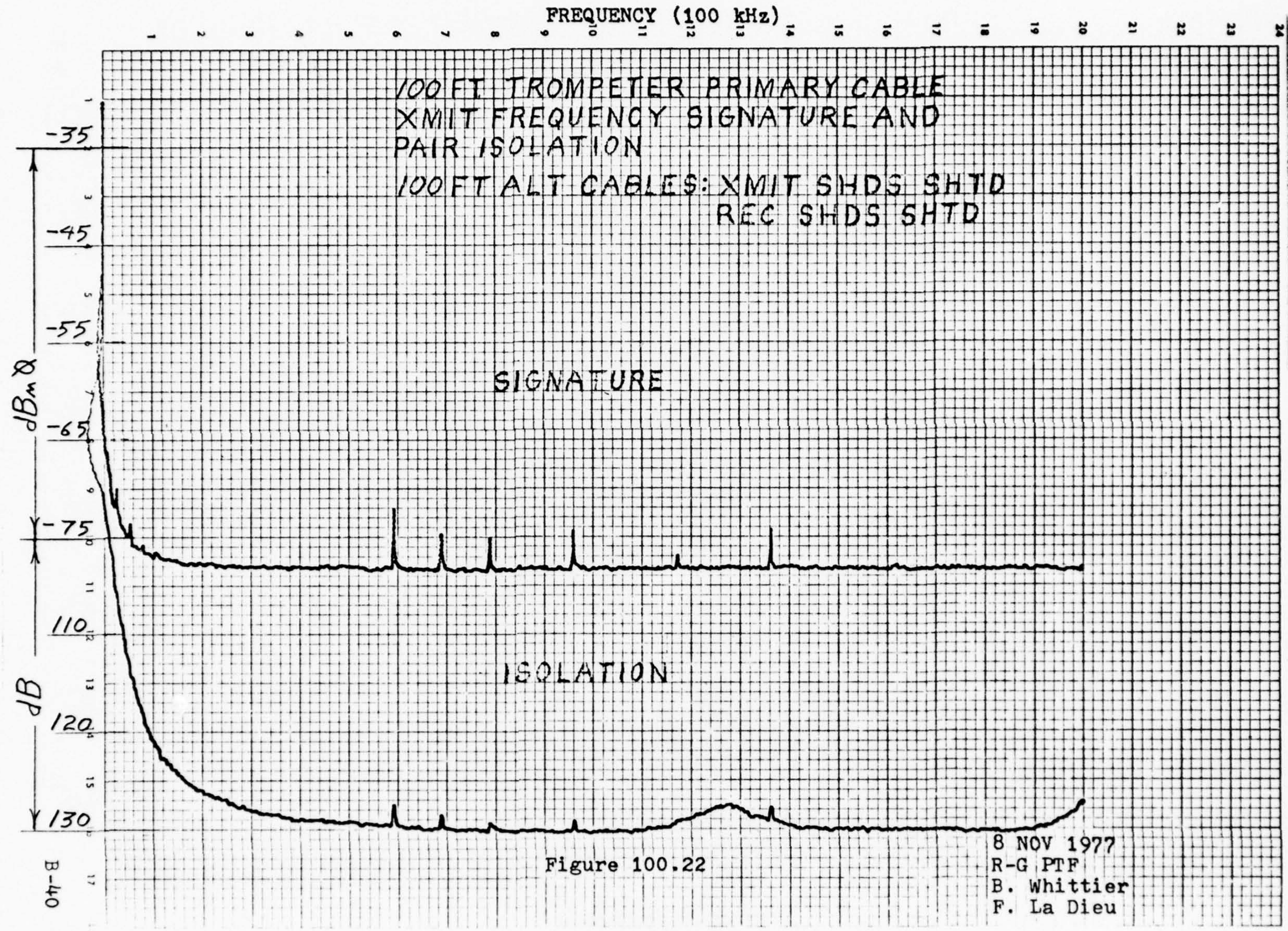
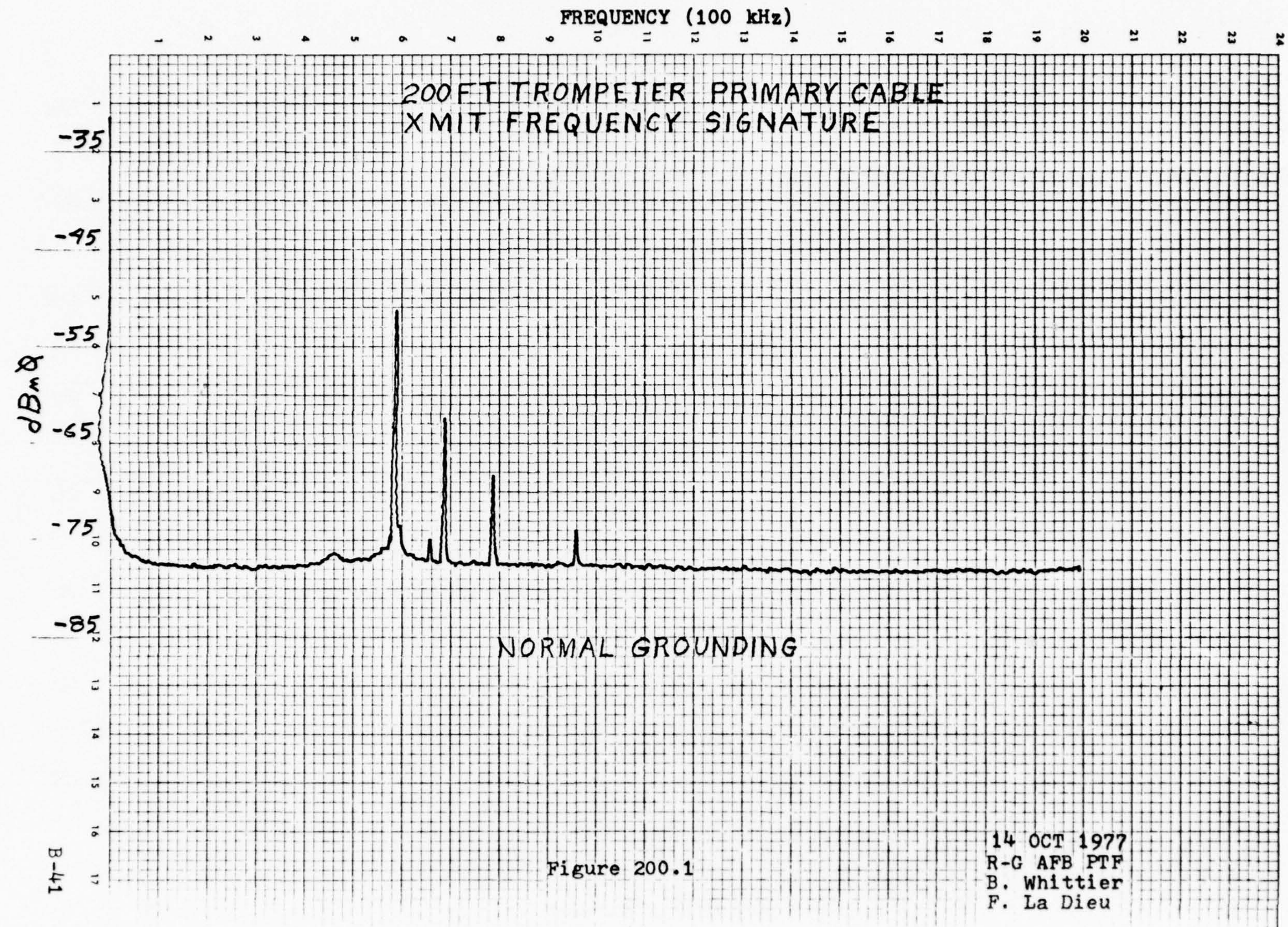


Figure 100.22



FREQUENCY (100 kHz)
200 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
-35
-45
-55
-65
-75
-85
dBmØ
NORMAL GROUNDING
14 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 200.1

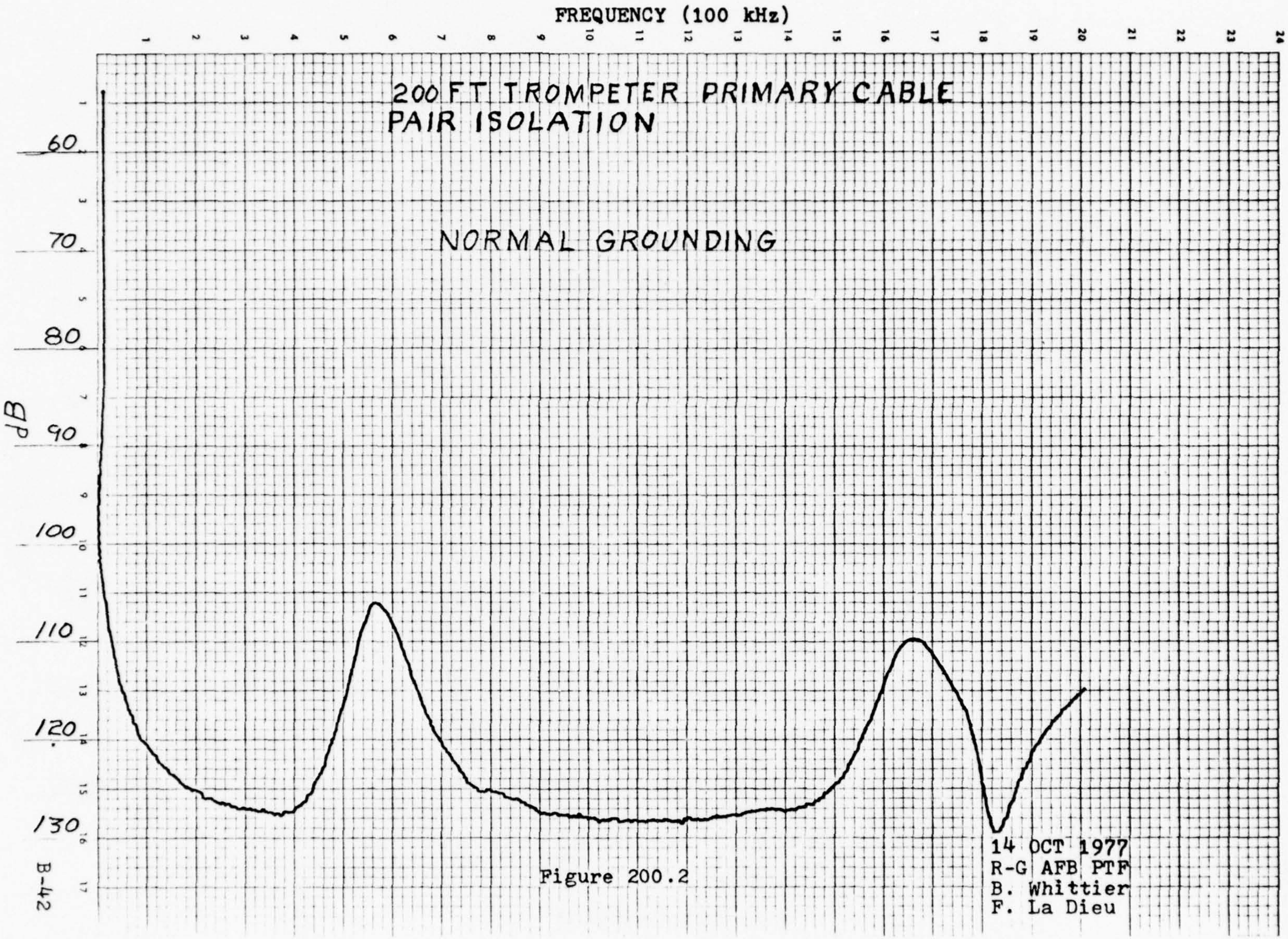
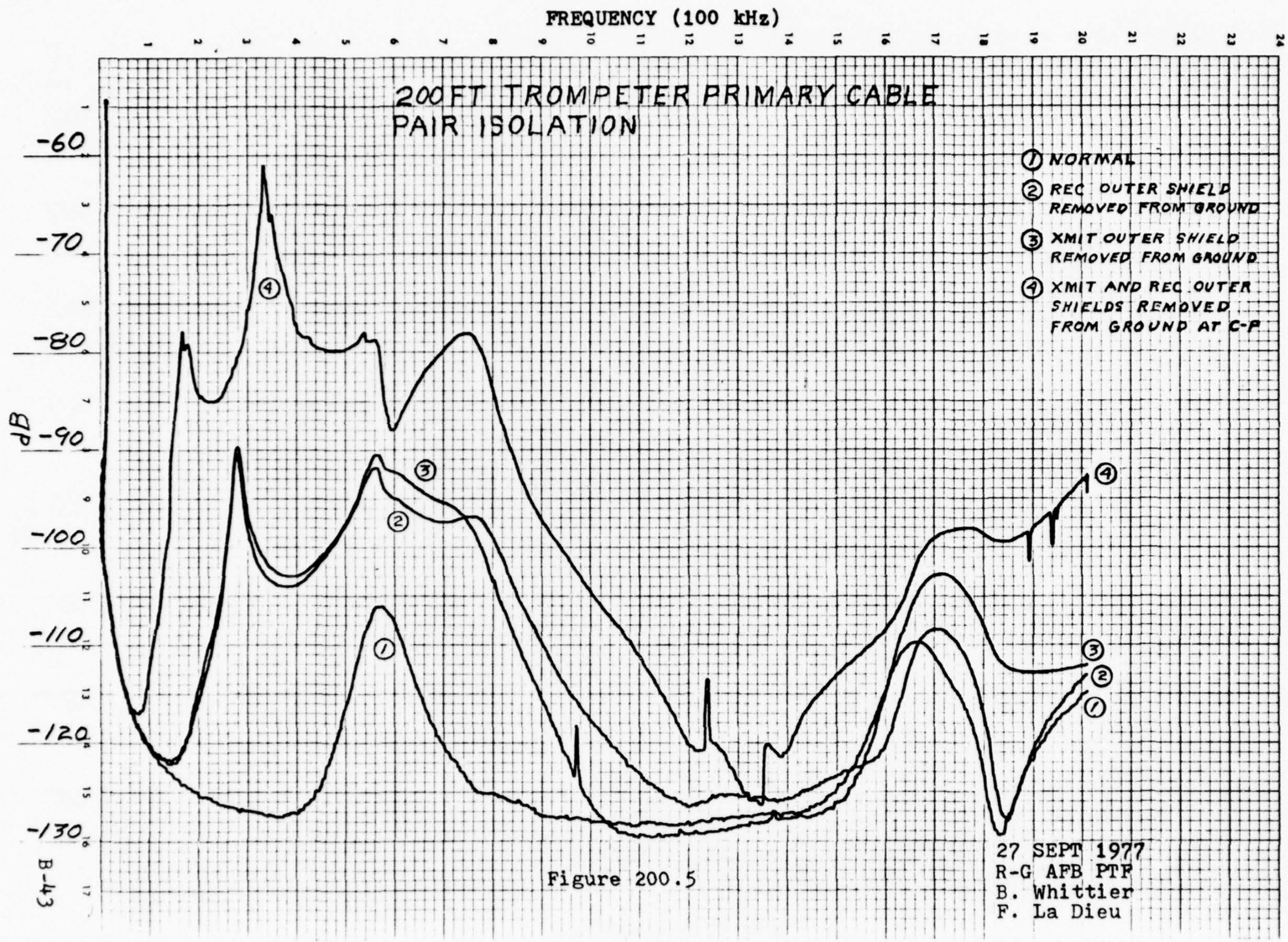
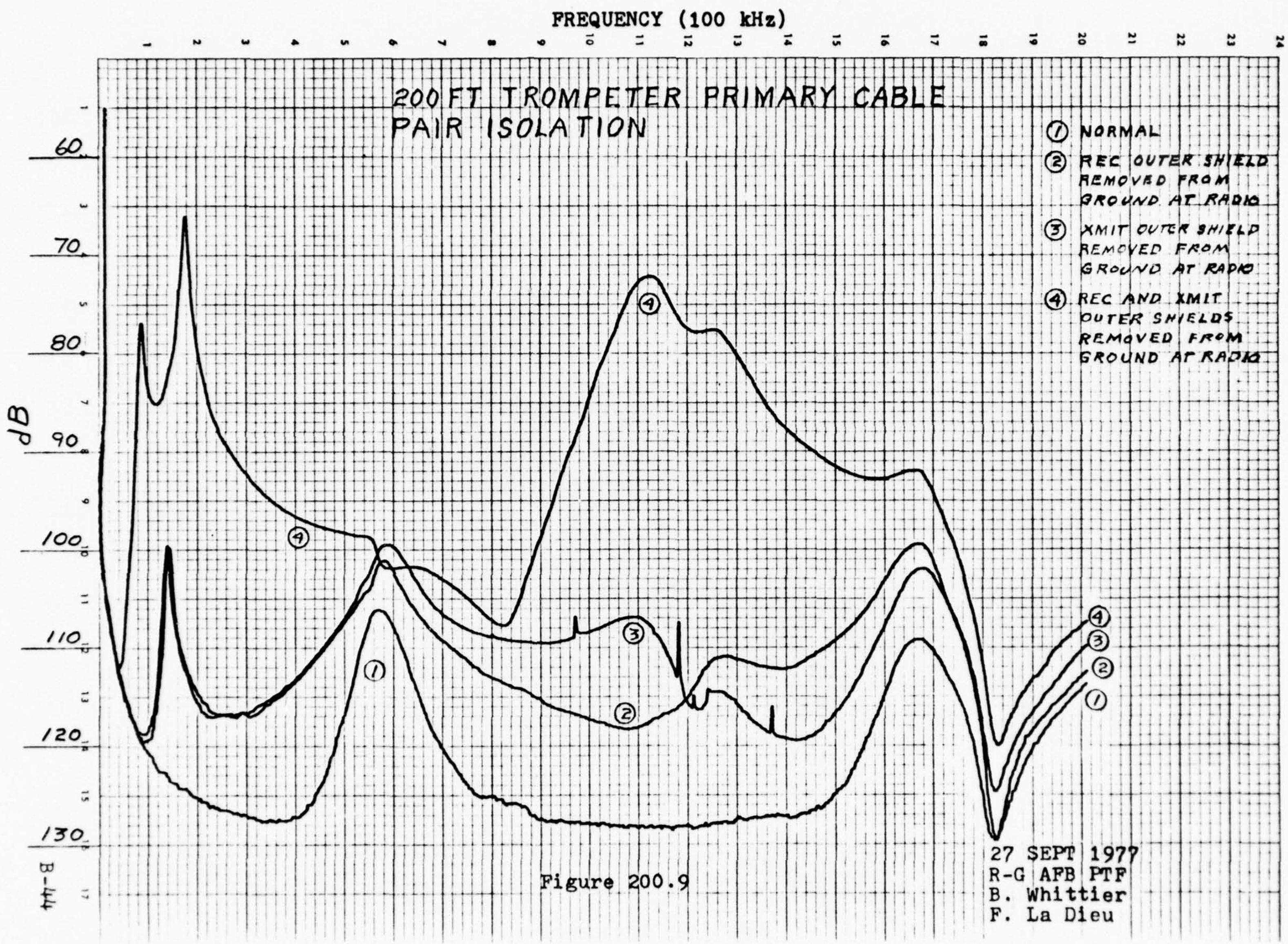

FREQUENCY (100 kHz)
200 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NORMAL GROUNDING
dB
60
70
80
90
100
110
120
130
14 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 200.2



FREQUENCY (100 kHz)
200FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
1 NORMAL
2 REC OUTER SHIELD REMOVED FROM GROUND
3 XMIT OUTER SHIELD REMOVED FROM GROUND
4 XMIT AND REC OUTER SHIELDS REMOVED FROM GROUND AT C-P
dB
-60
-70
-80
-90
-100
-110
-120
-130
27 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 200.5



FREQUENCY (100 kHz)
200 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
① NORMAL
② REC OUTER SHIELD REMOVED FROM GROUND AT RADIO
③ XMIT OUTER SHIELD REMOVED FROM GROUND AT RADIO
④ REC AND XMIT OUTER SHIELDS REMOVED FROM GROUND AT RADIO
dB
60
70
80
90
100
110
120
130
27 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 200.9

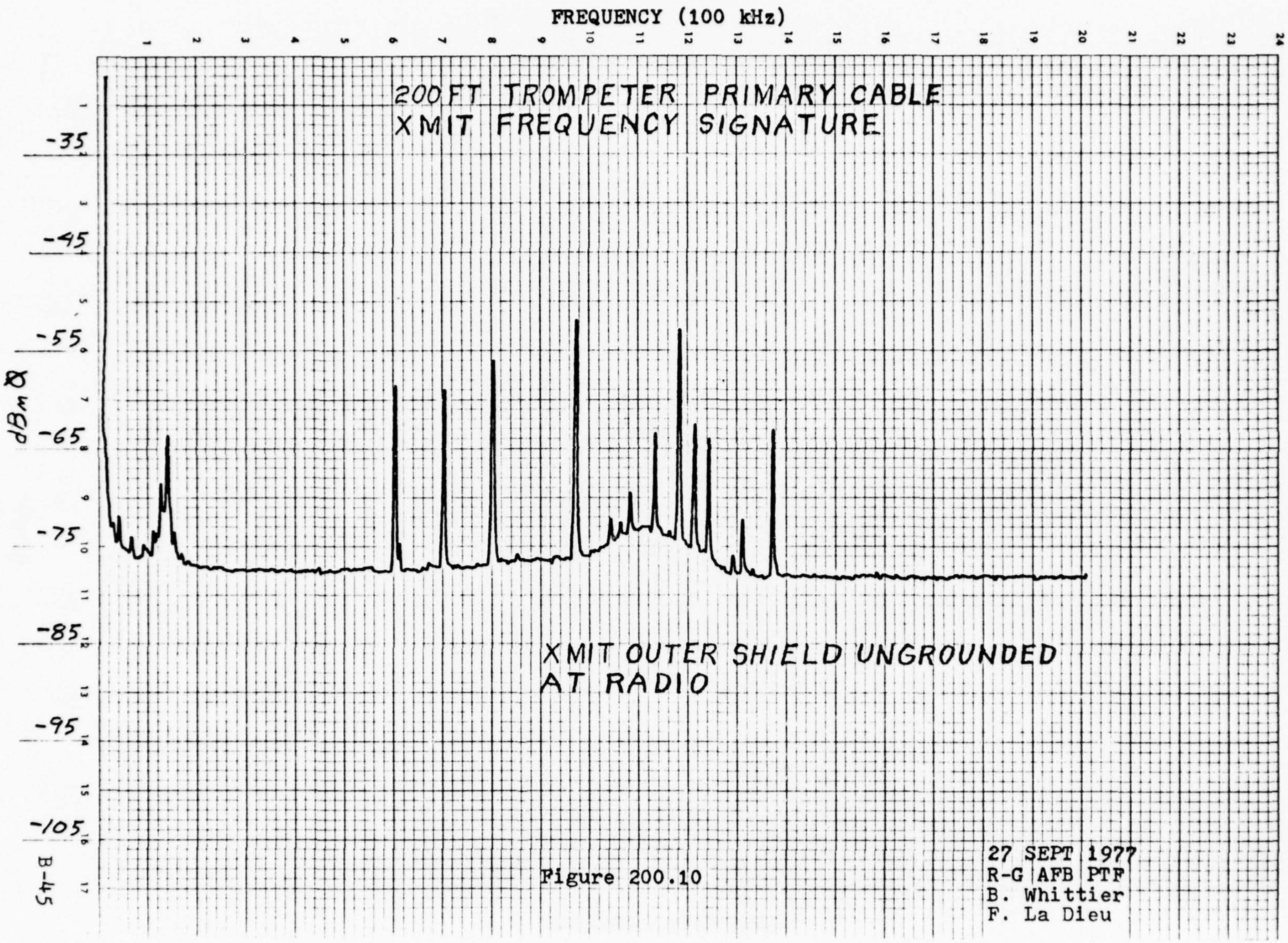


Figure 200.10

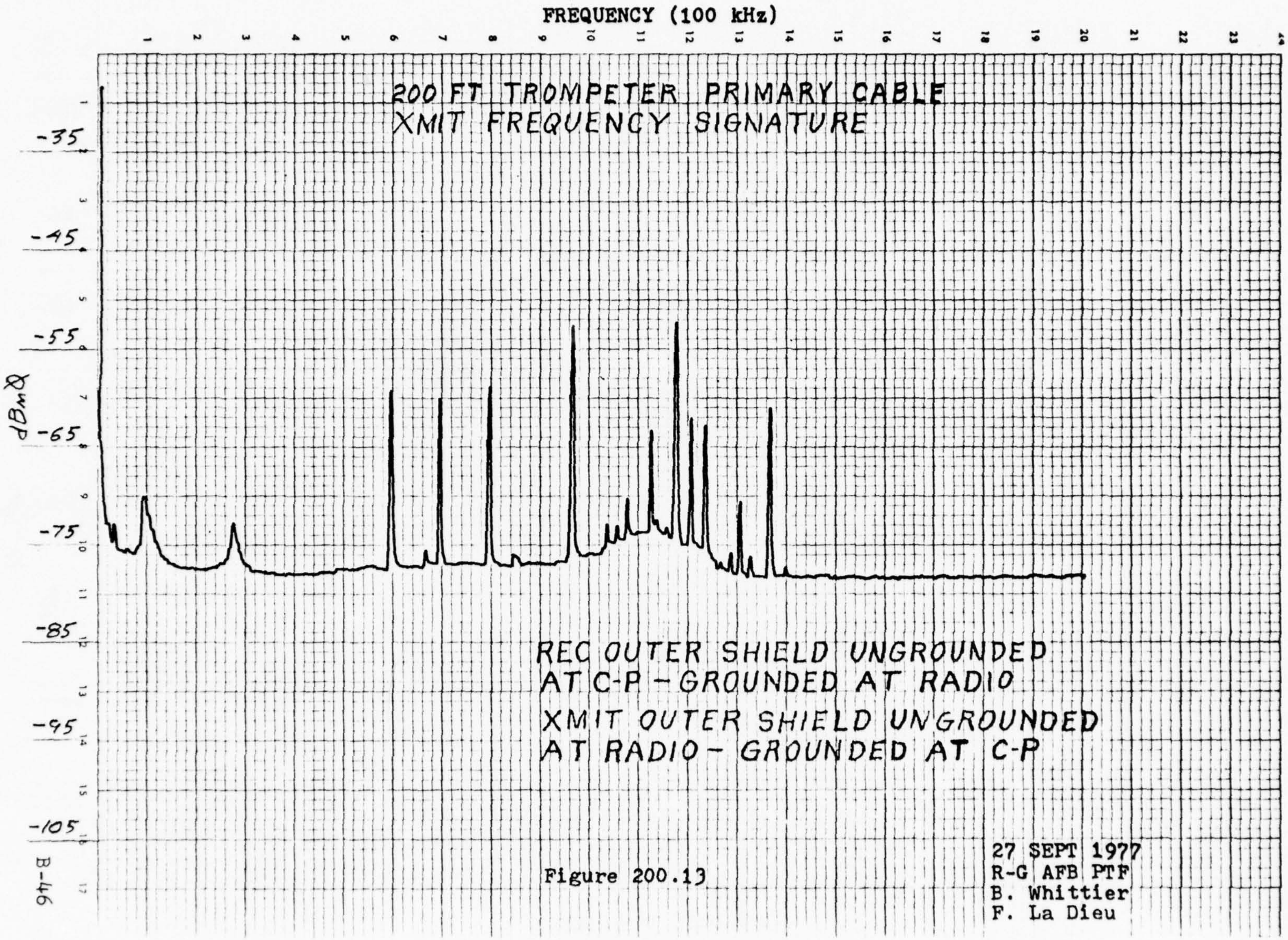


Figure 200.13

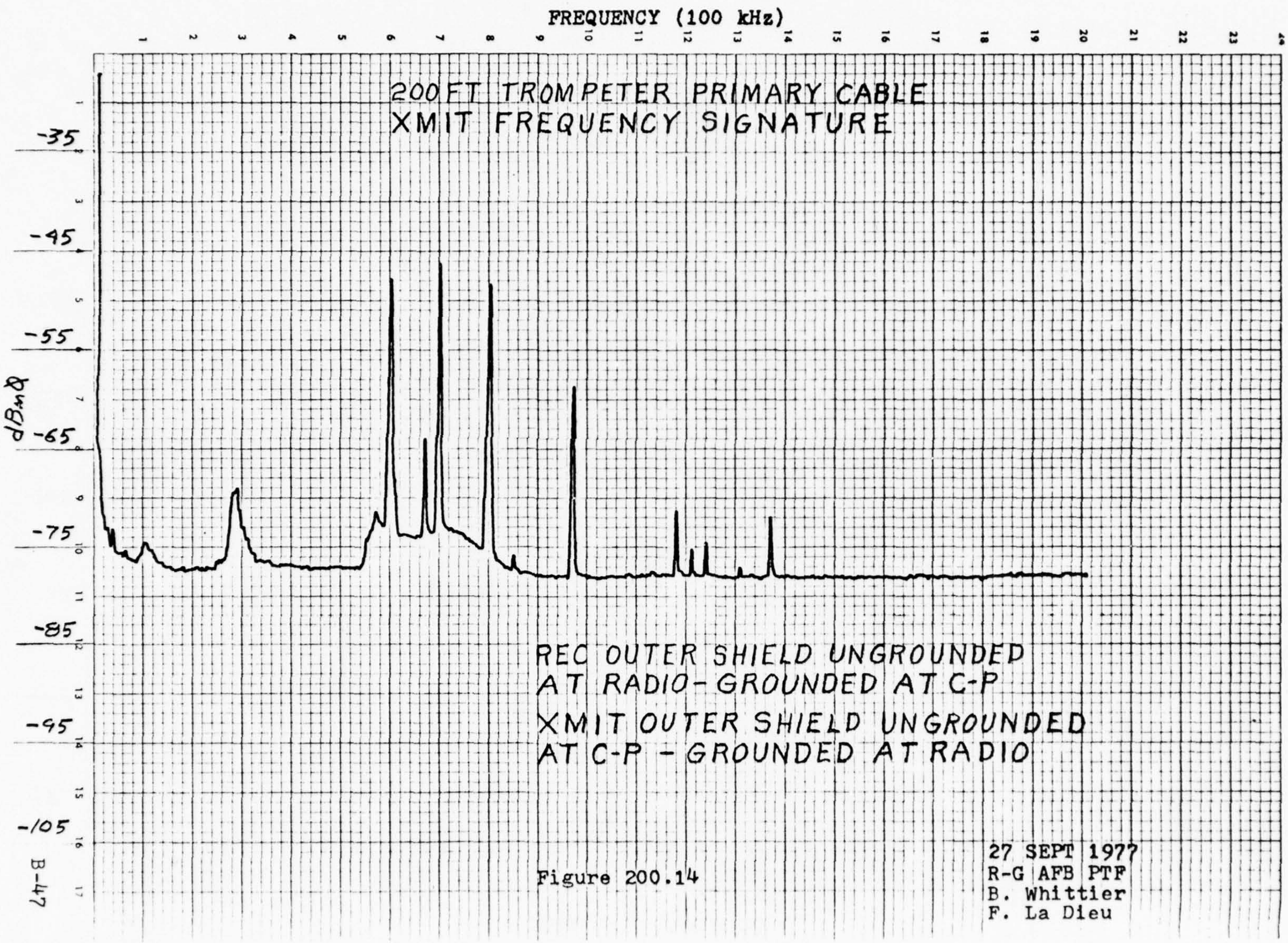


Figure 200.14

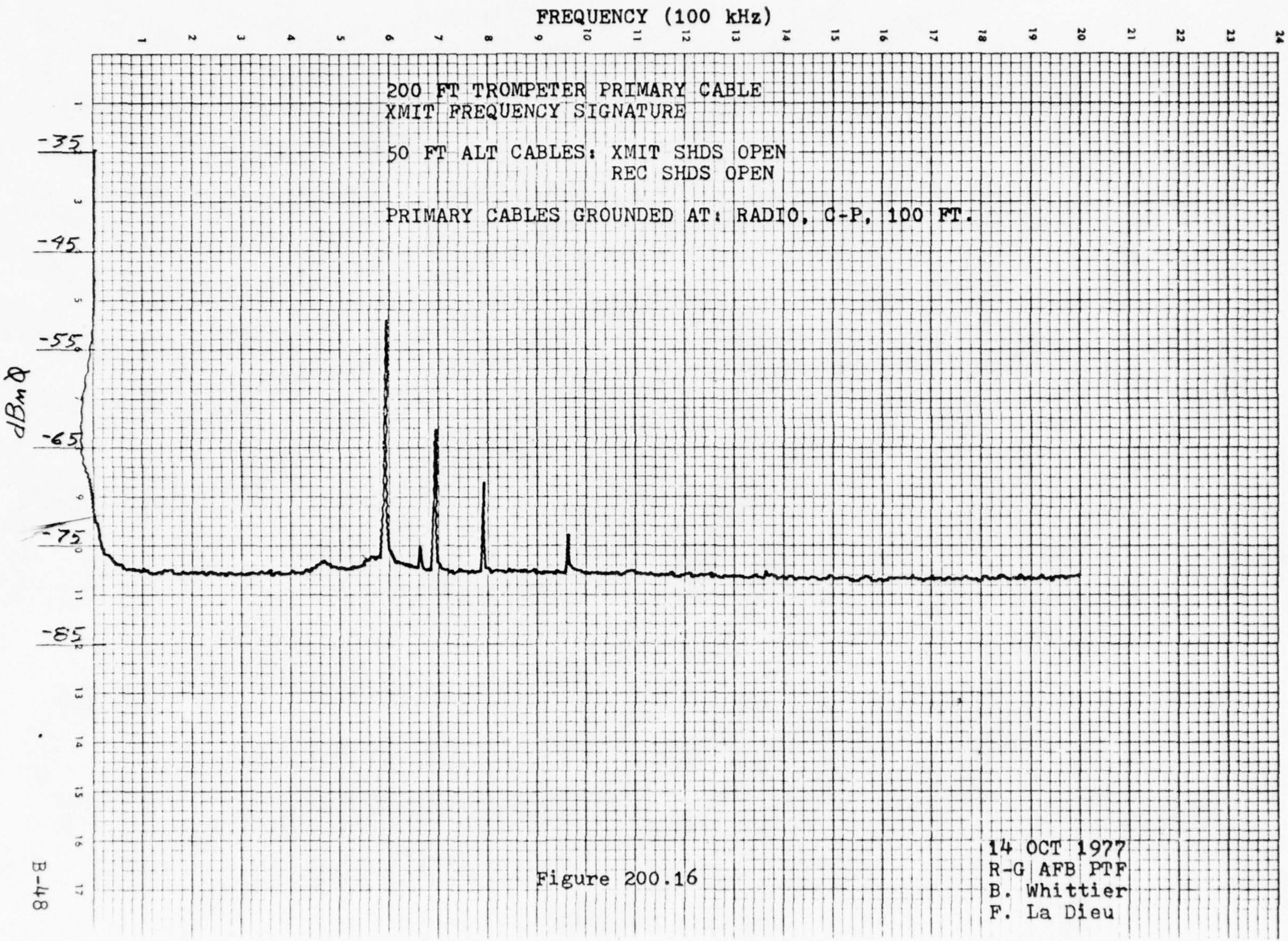


Figure 200.16

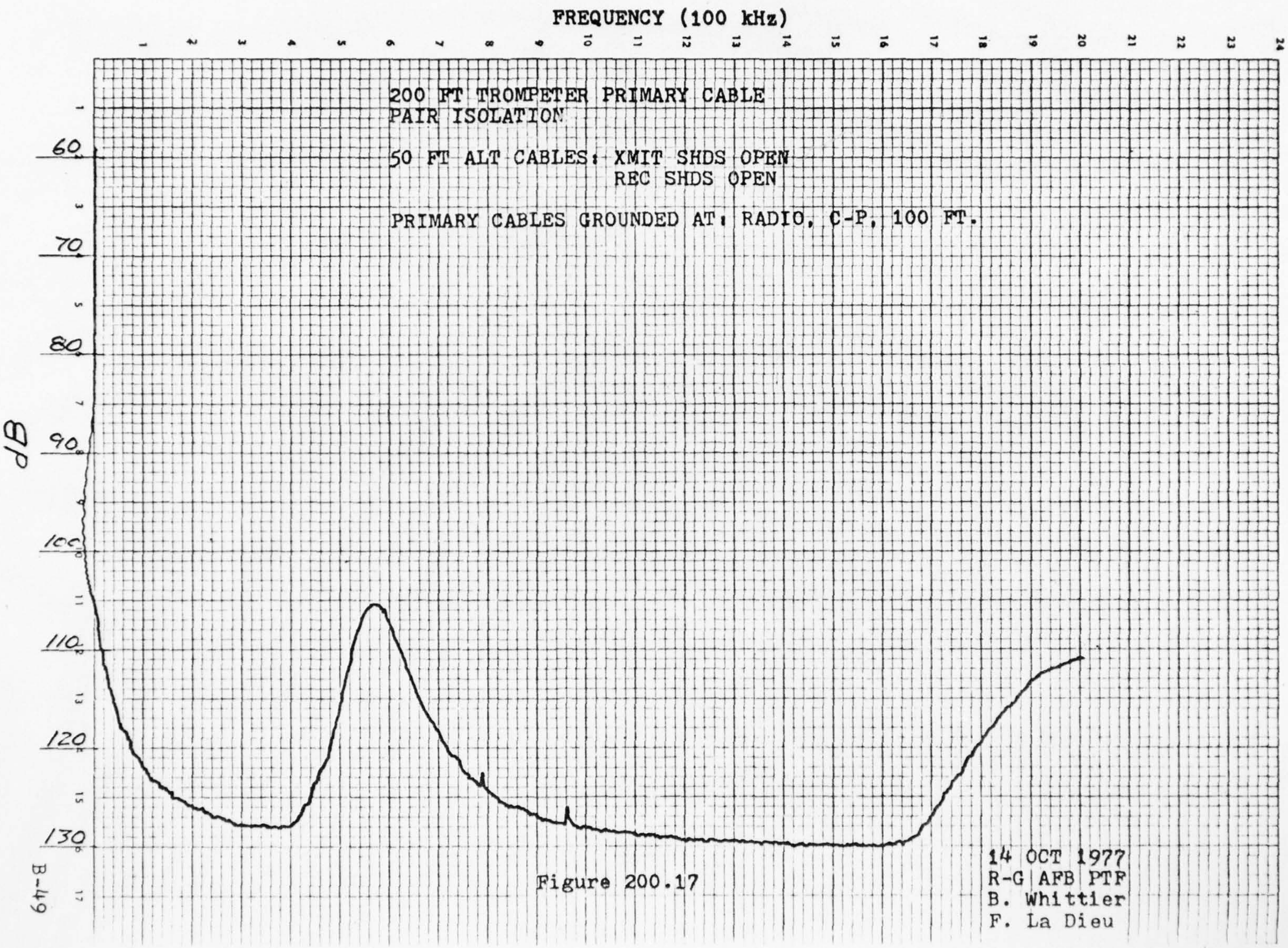


Figure 200.17

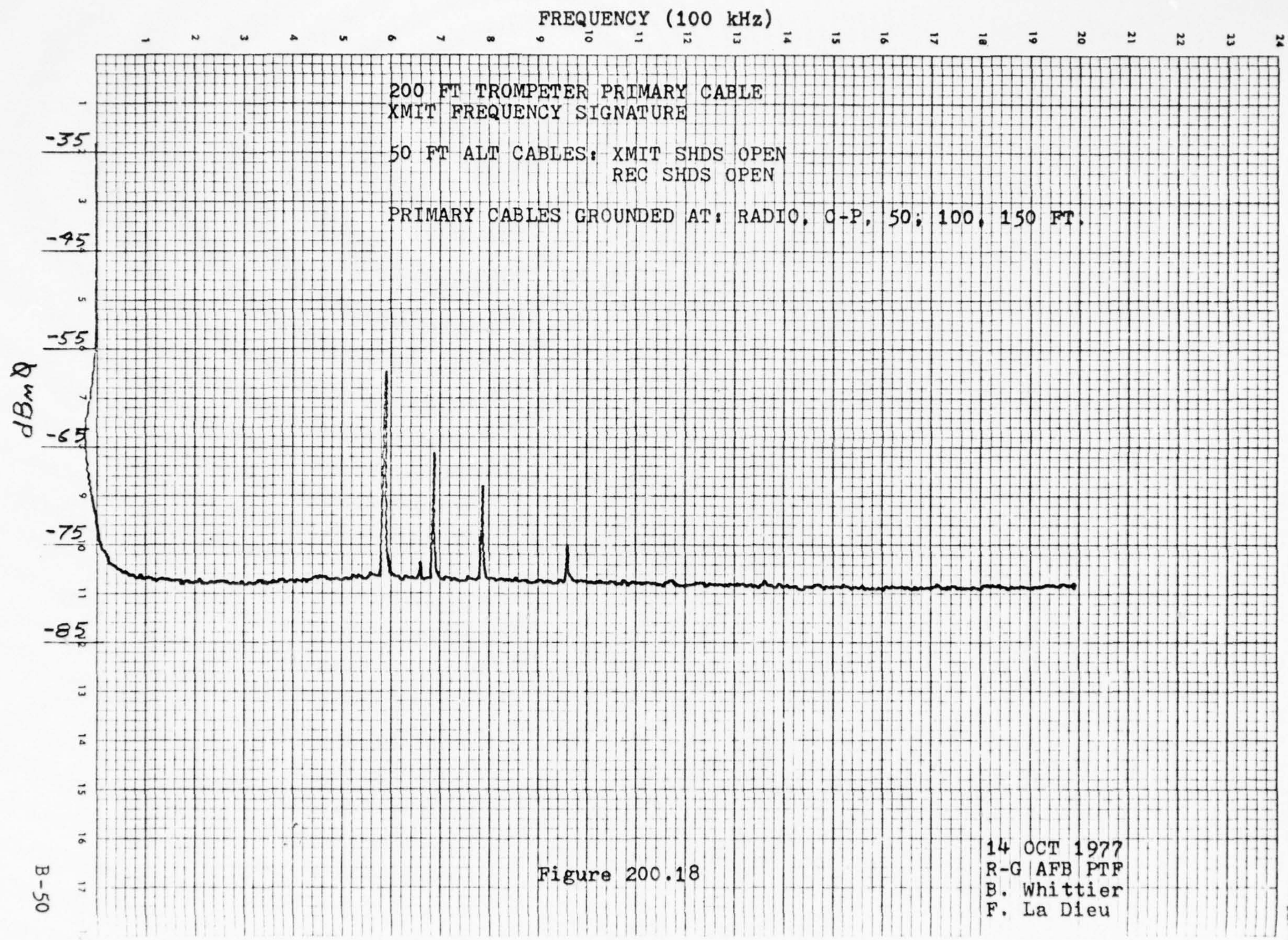


Figure 200.18

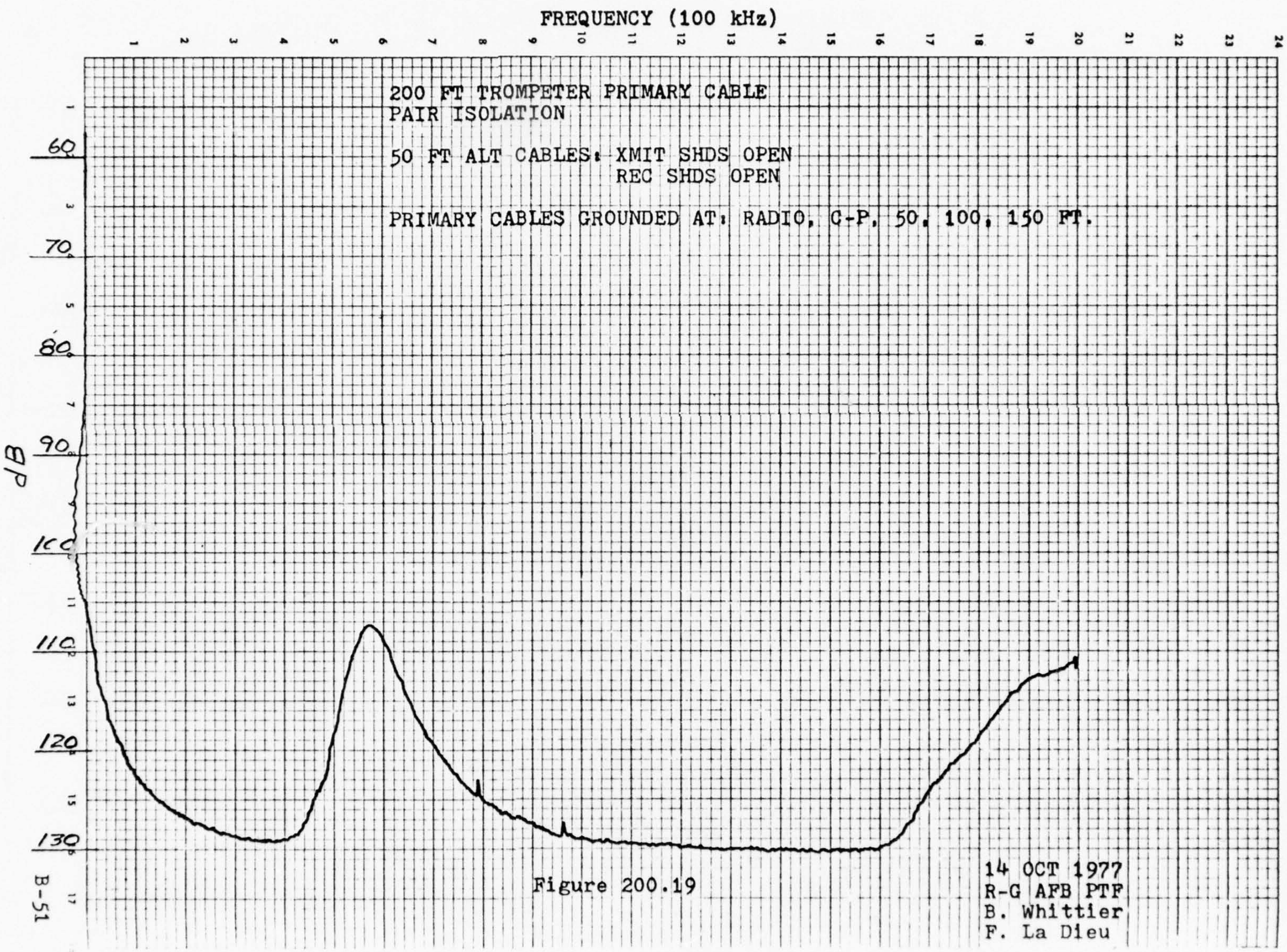


Figure 200.19

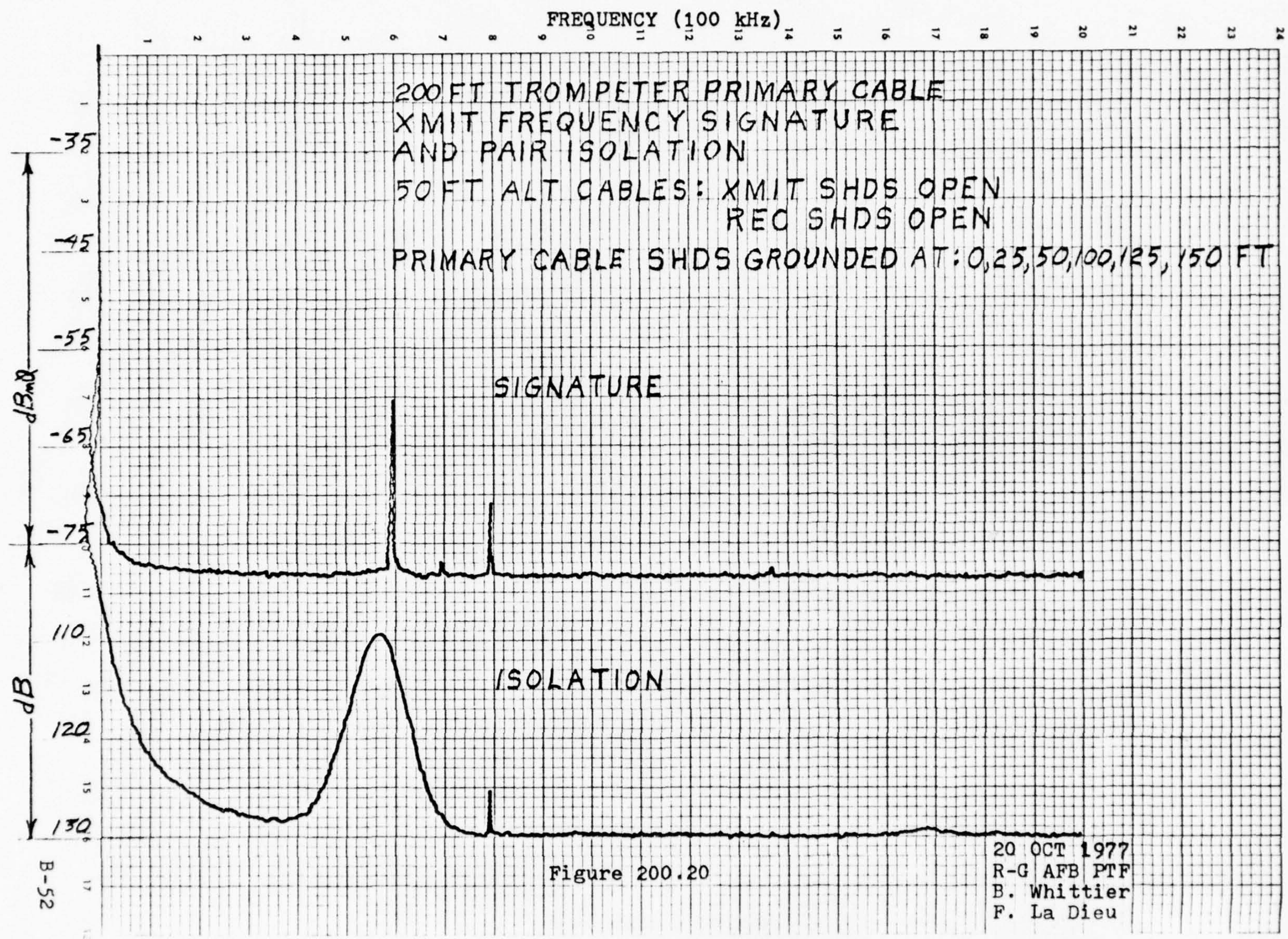


Figure 200.20

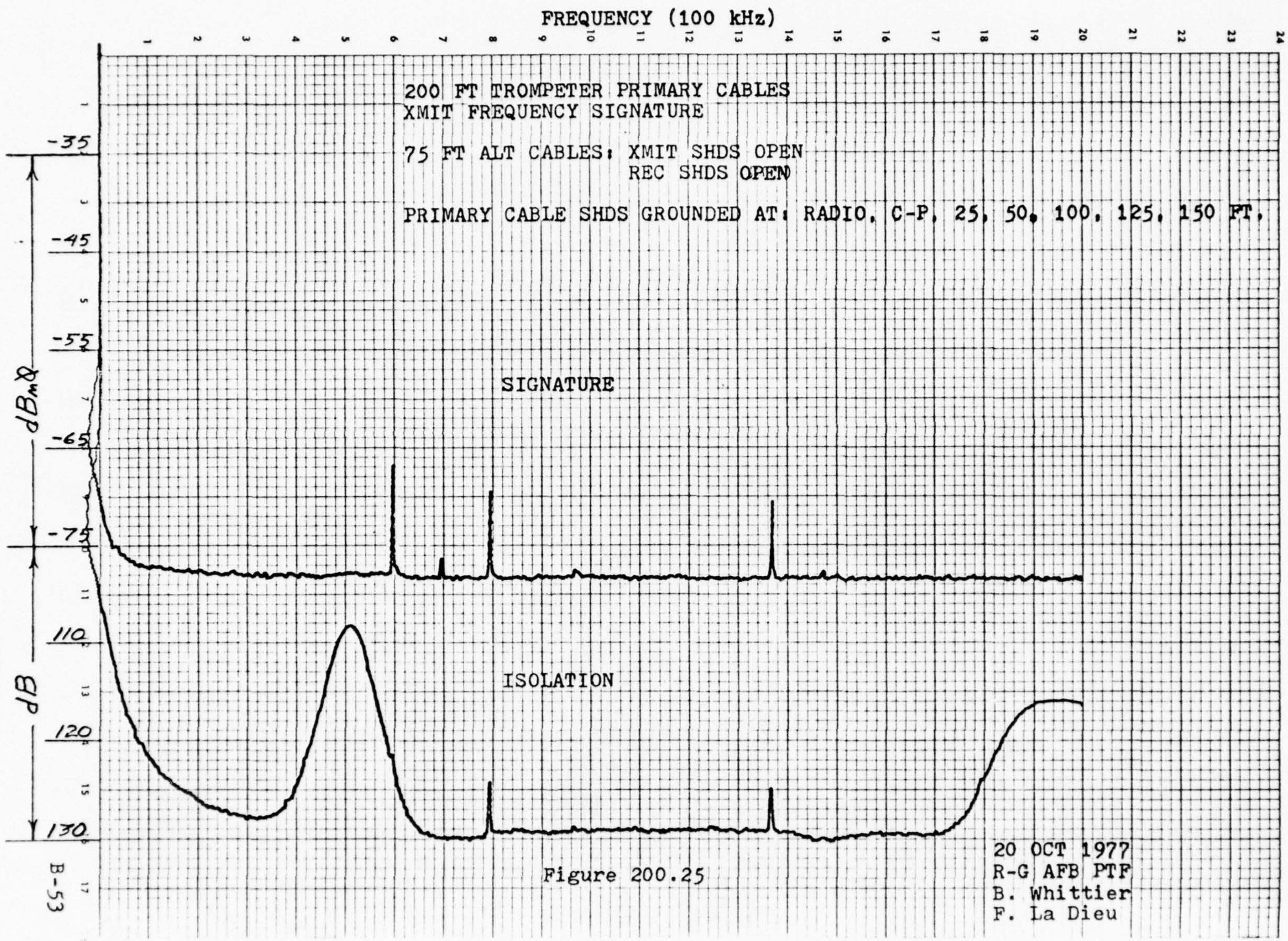


Figure 200.25

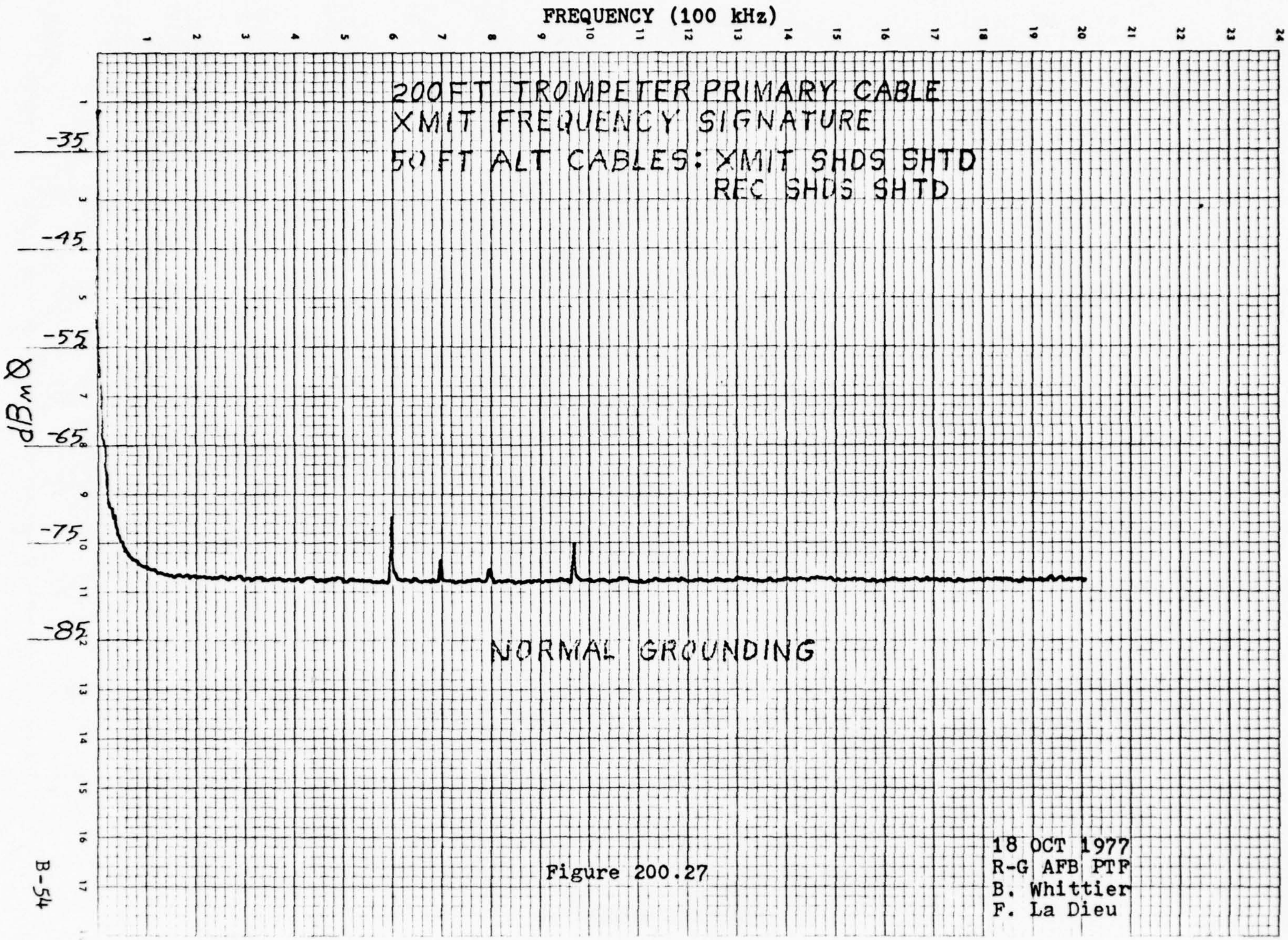


Figure 200.27

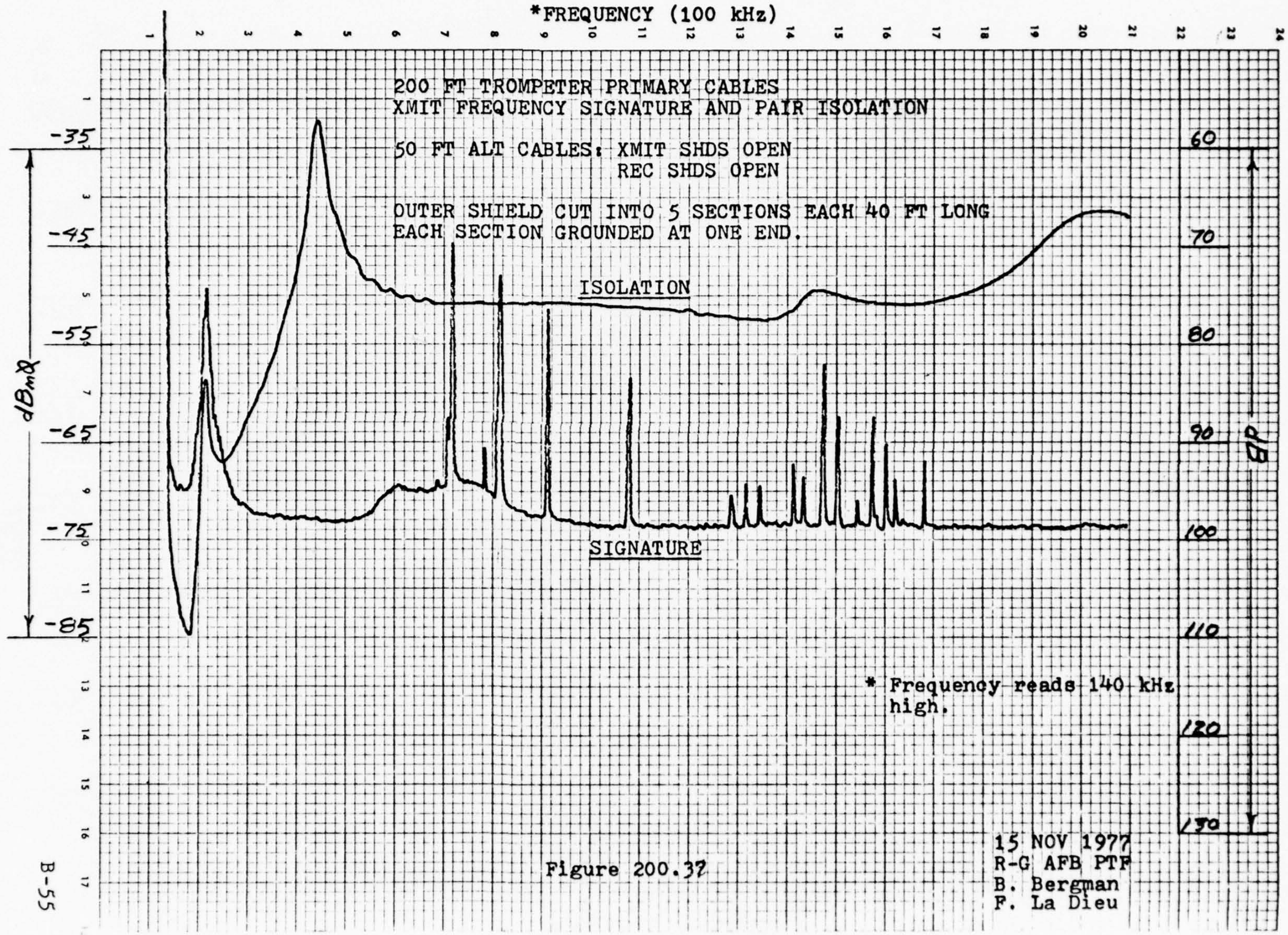


Figure 200.37

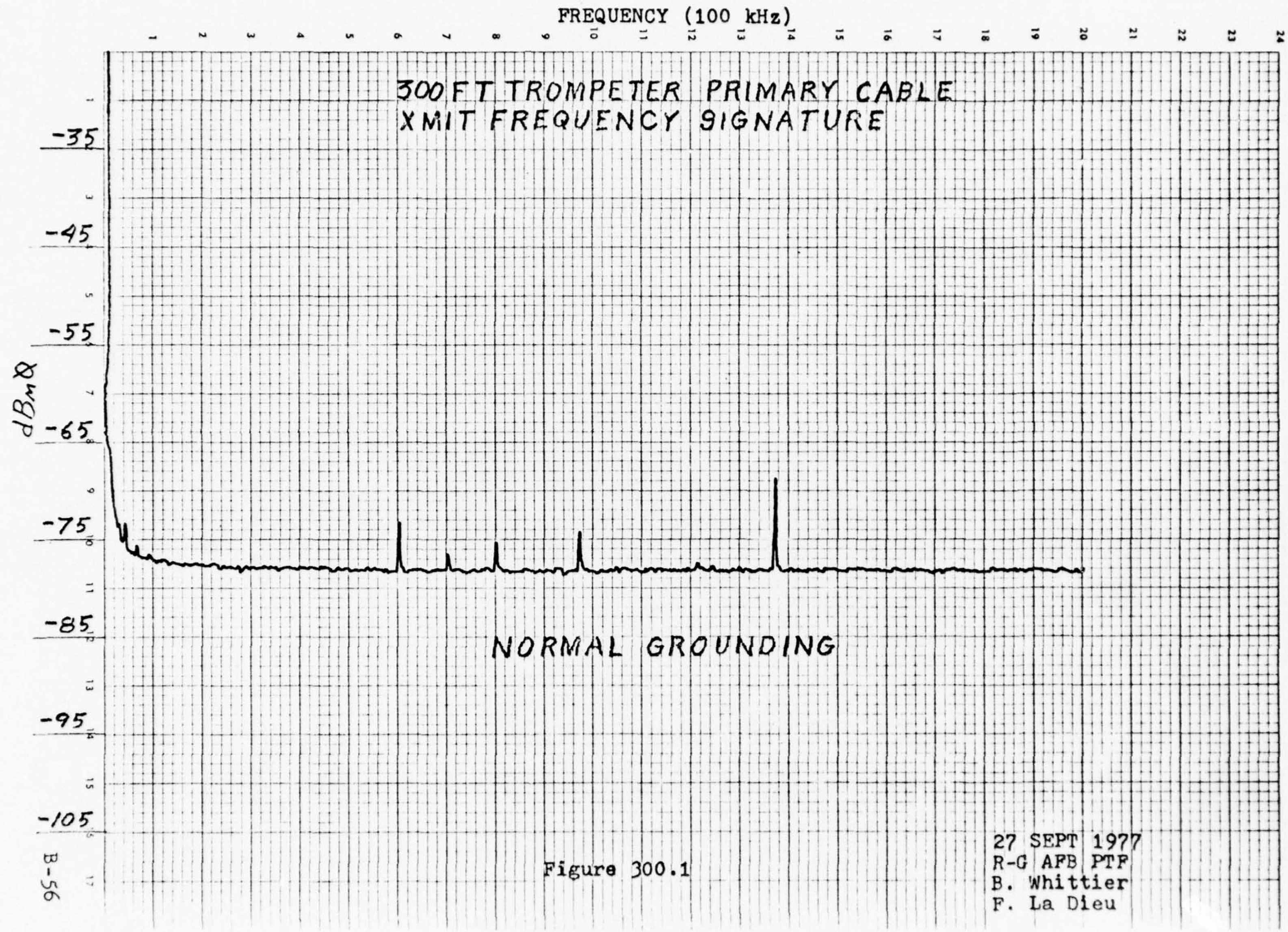

FREQUENCY (100 kHz)
300 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NORMAL GROUNDING
dBmO
-35
-45
-55
-65
-75
-85
-95
-105
27 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 300.1

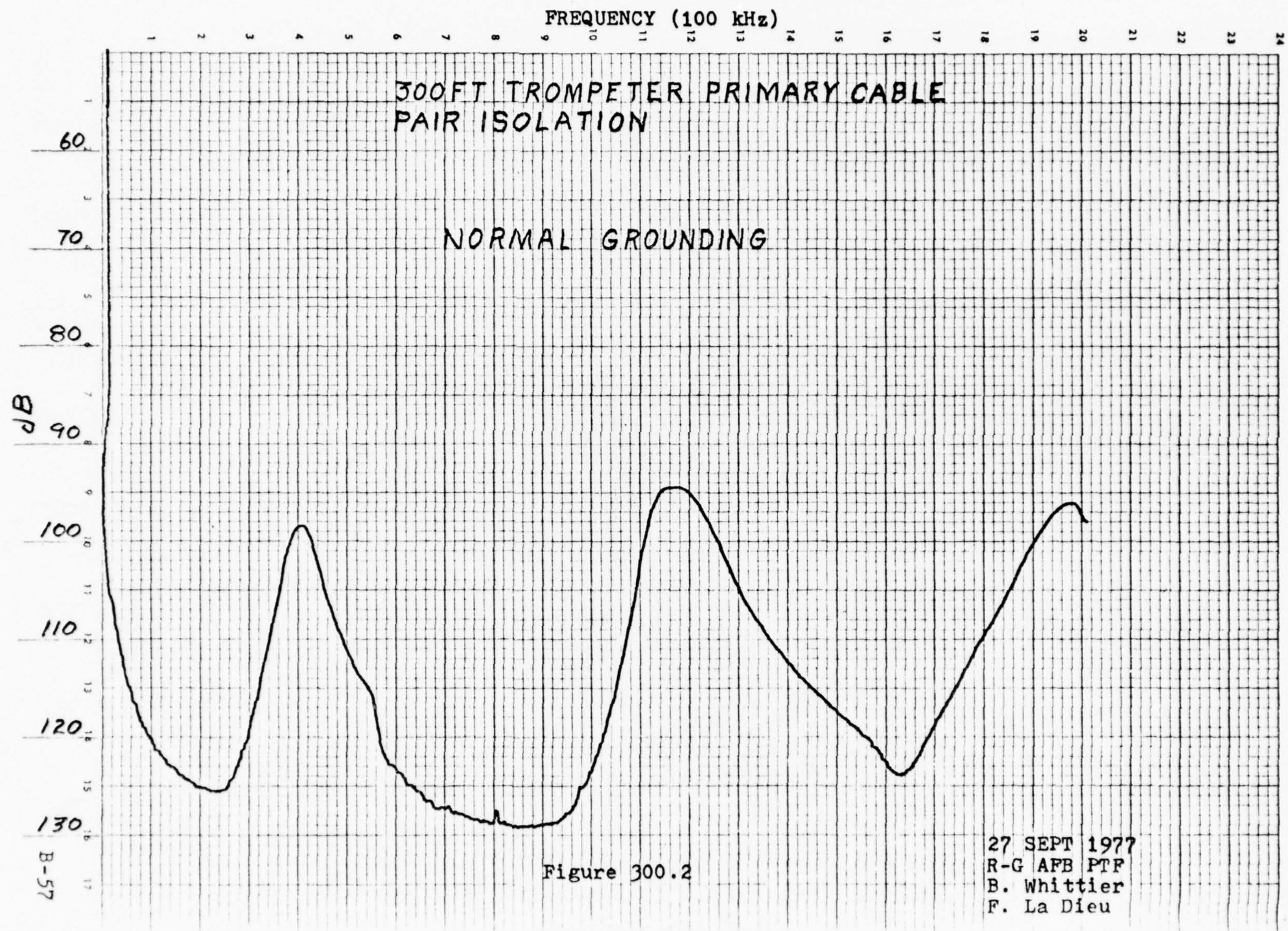

FREQUENCY (100 kHz)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
300FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NORMAL GROUNDING
dB
60
70
80
90
100
110
120
130
27 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 300.2

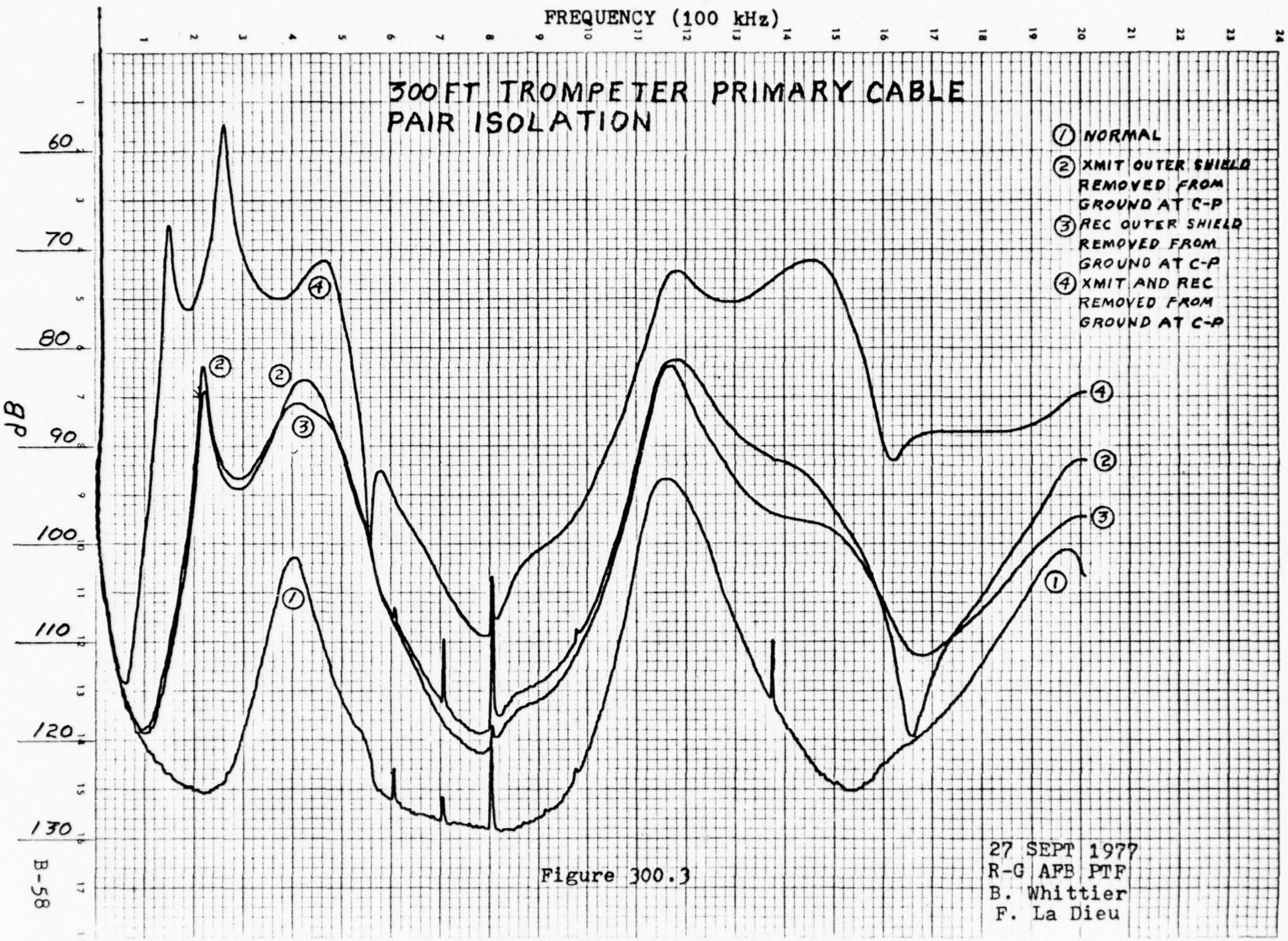

FREQUENCY (100 kHz)
300FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
① NORMAL
② XMIT OUTER SHIELD REMOVED FROM GROUND AT C-P
③ REC OUTER SHIELD REMOVED FROM GROUND AT C-P
④ XMIT AND REC REMOVED FROM GROUND AT C-P
dB
60
70
80
90
100
110
120
130
27 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 300.3

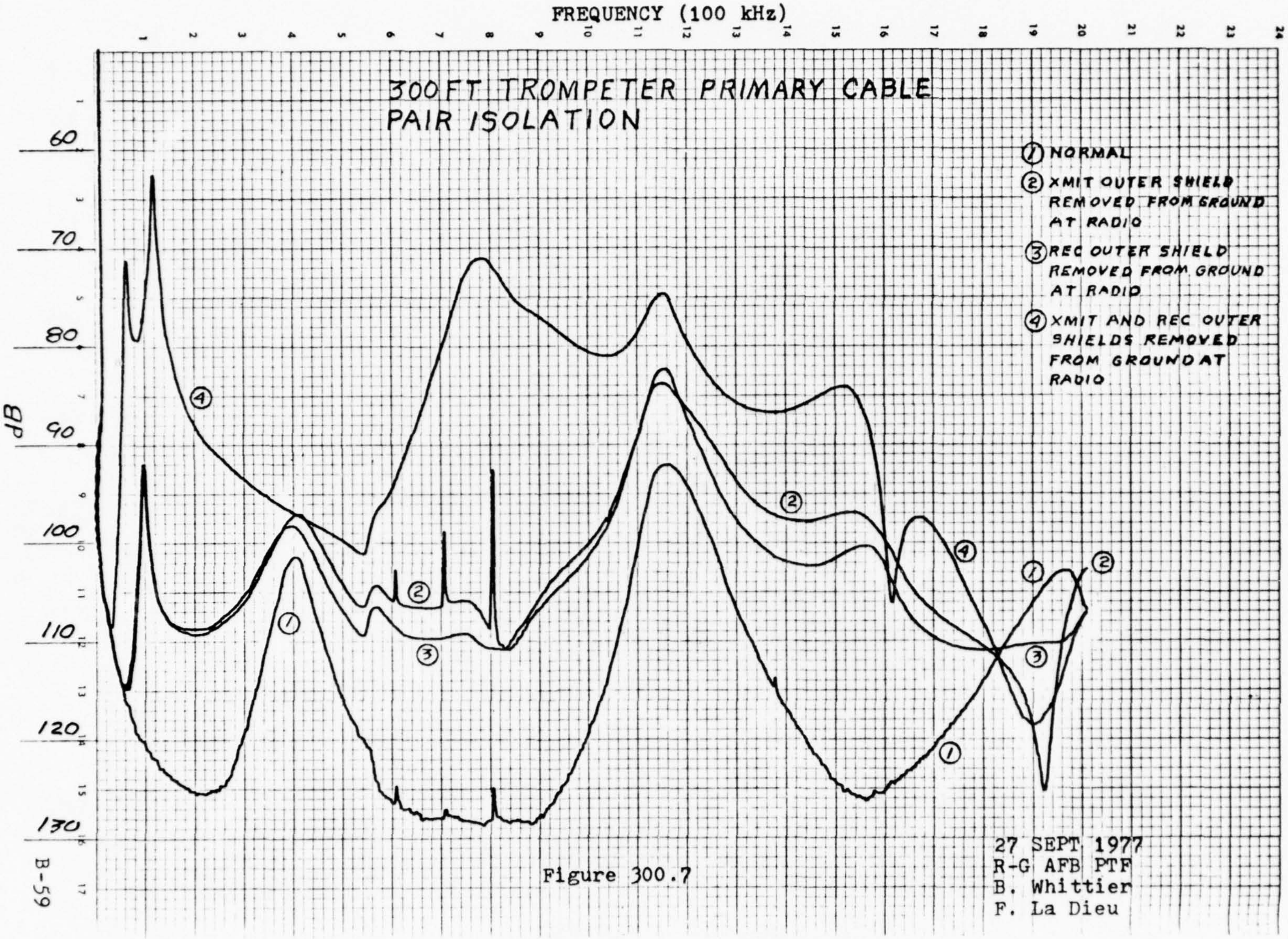

300FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
FREQUENCY (100 kHz)
dB
60
70
80
90
100
110
120
130
① NORMAL
② XMIT OUTER SHIELD REMOVED FROM GROUND AT RADIO
③ REC OUTER SHIELD REMOVED FROM GROUND AT RADIO
④ XMIT AND REC OUTER SHIELDS REMOVED FROM GROUND AT RADIO
27 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 300.7

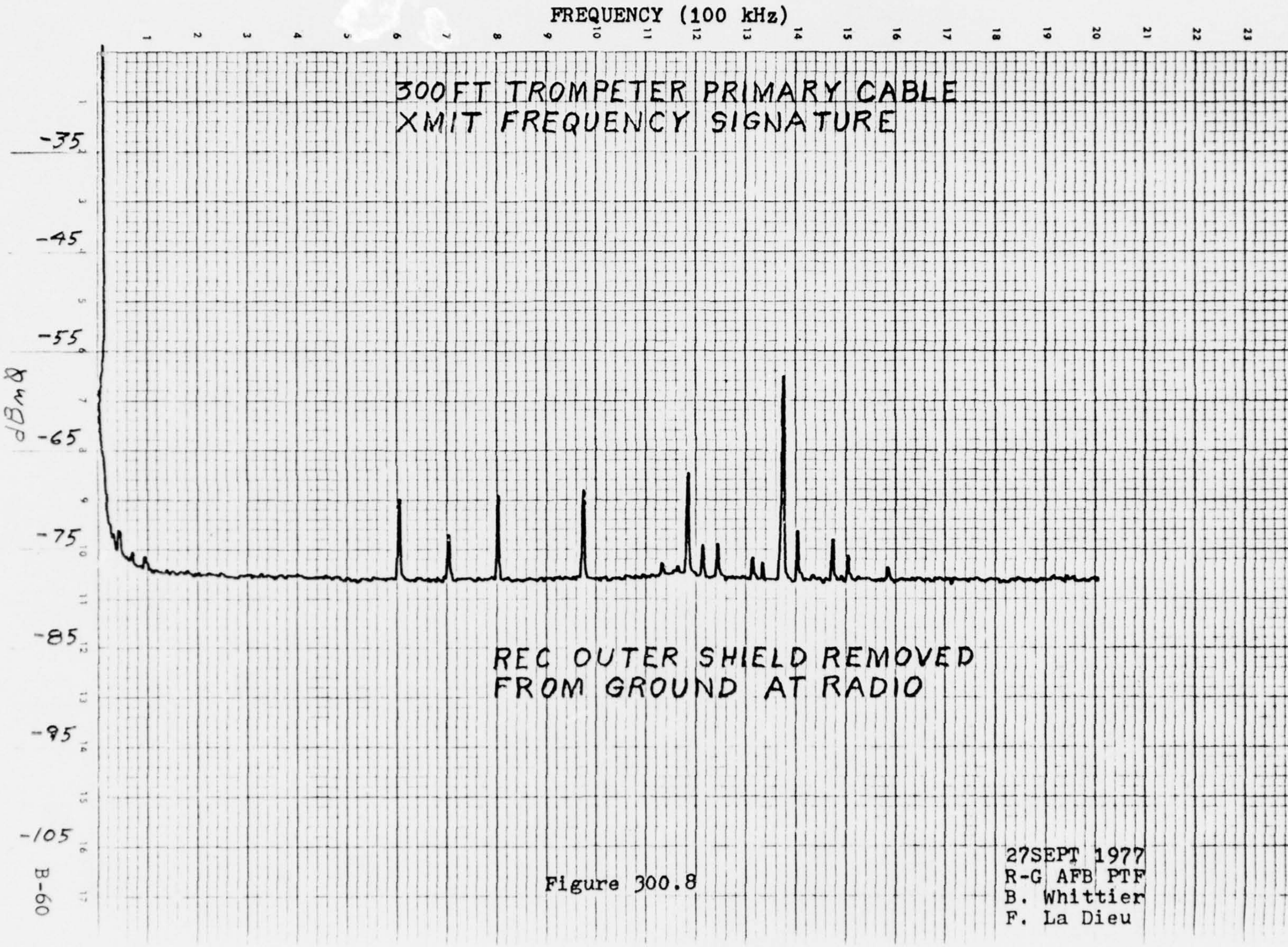

FREQUENCY (100 kHz)
300FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
REC OUTER SHIELD REMOVED
FROM GROUND AT RADIO
dBm
-35
-45
-55
-65
-75
-85
-95
-105
27SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 300.8

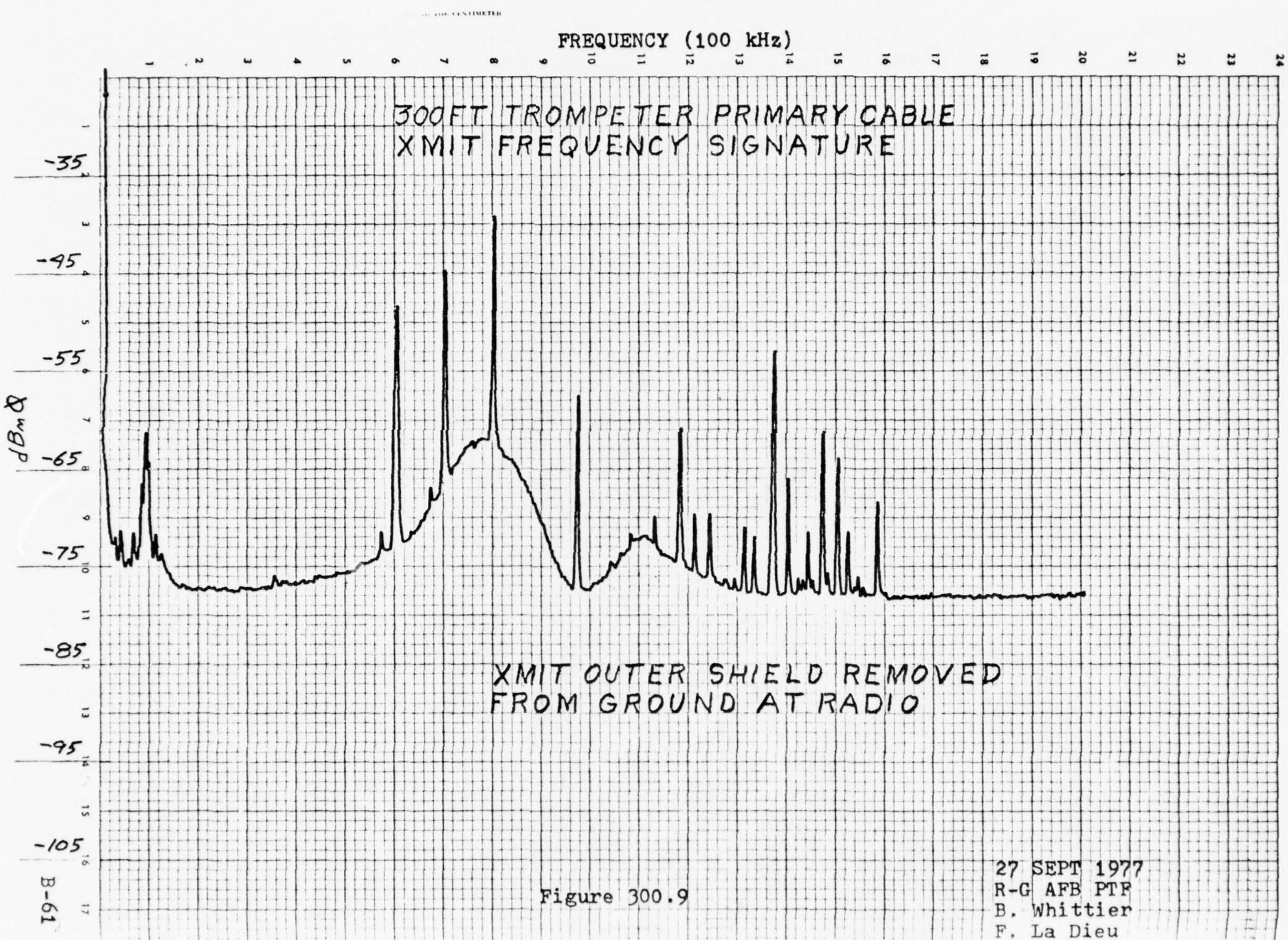

FREQUENCY (100 kHz)
300FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
XMIT OUTER SHIELD REMOVED
FROM GROUND AT RADIO
dBm
-35
-45
-55
-65
-75
-85
-95
-105
27 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 300.9

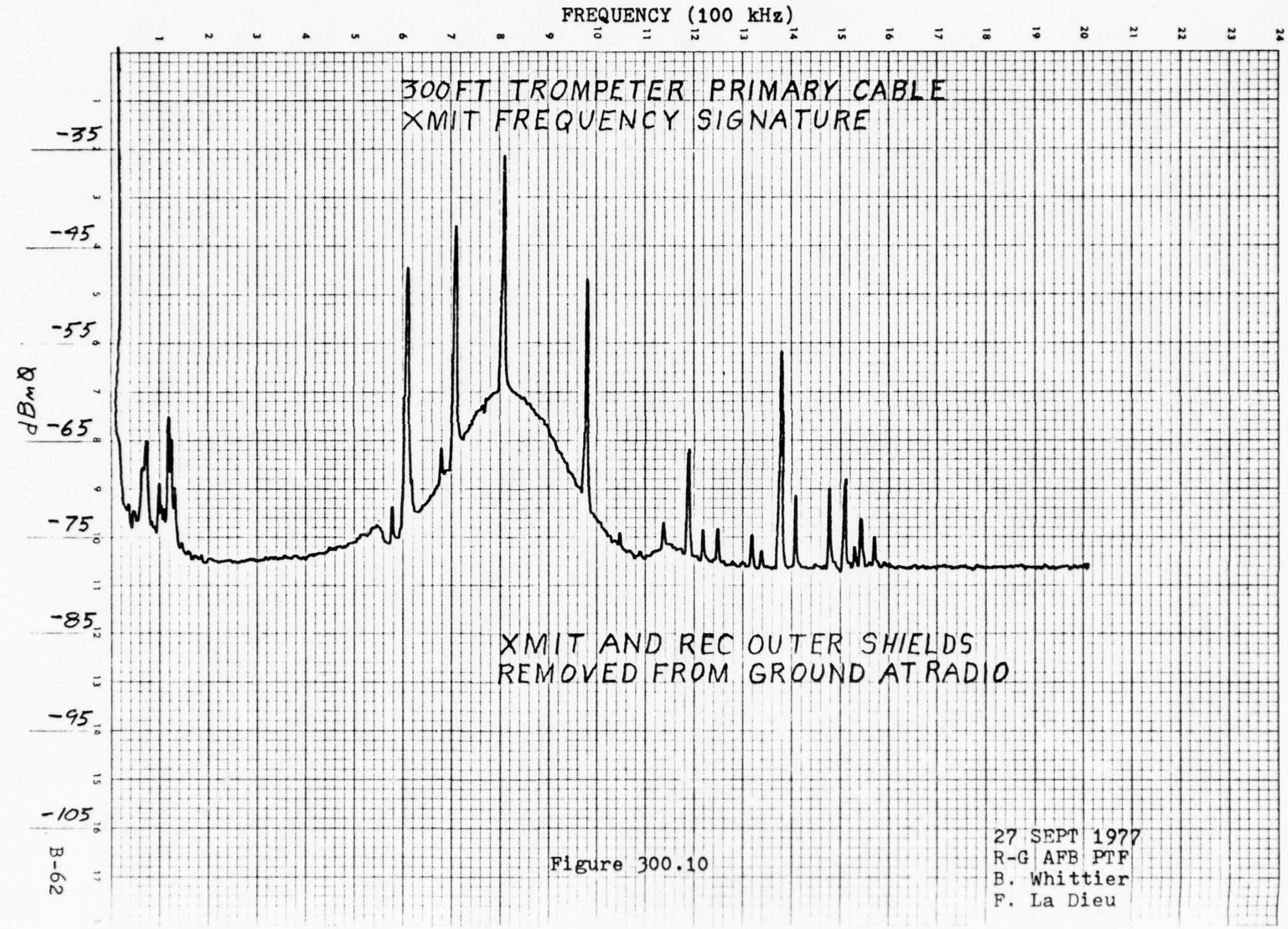


Figure 300.10

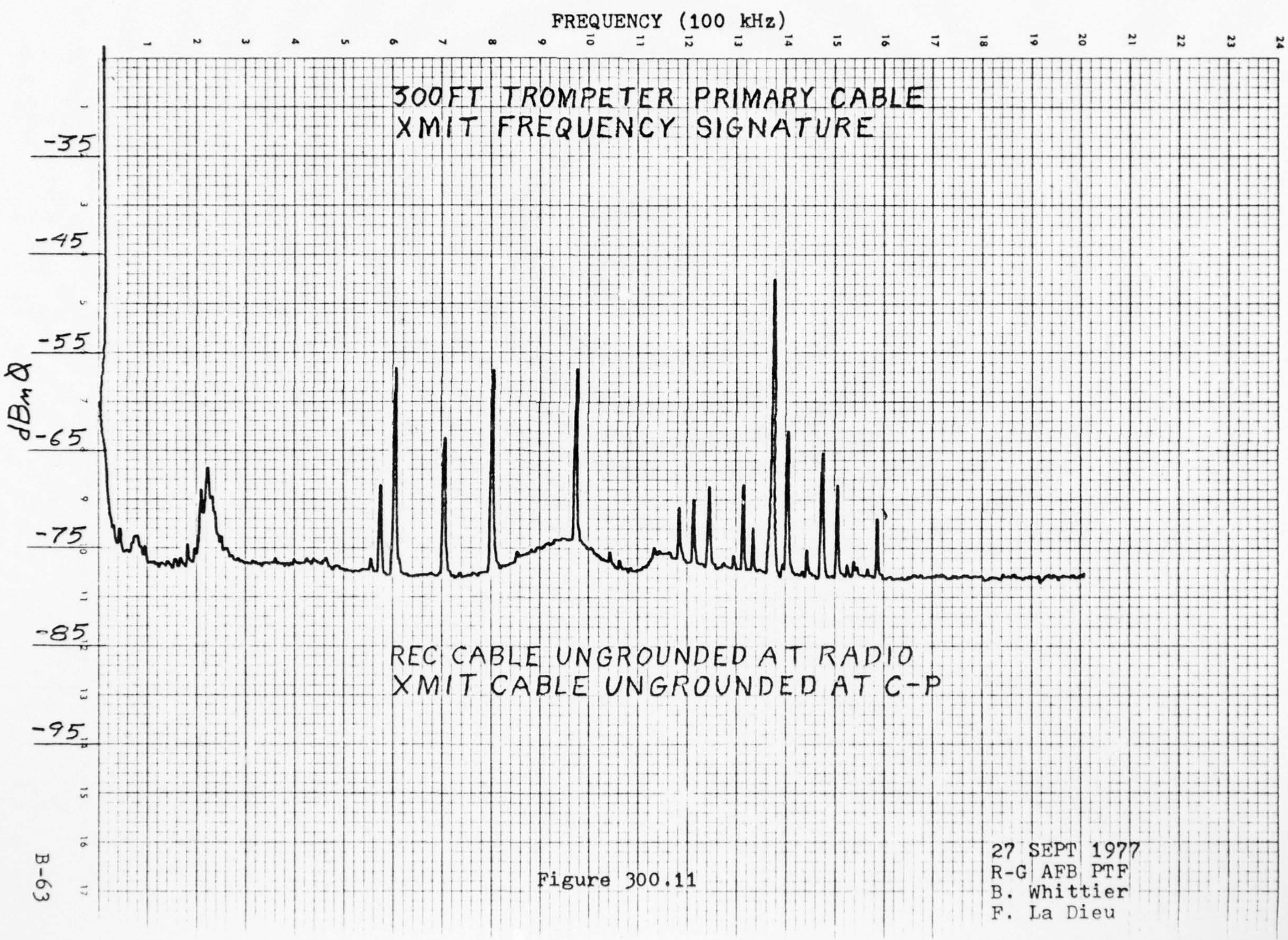


Figure 300.11

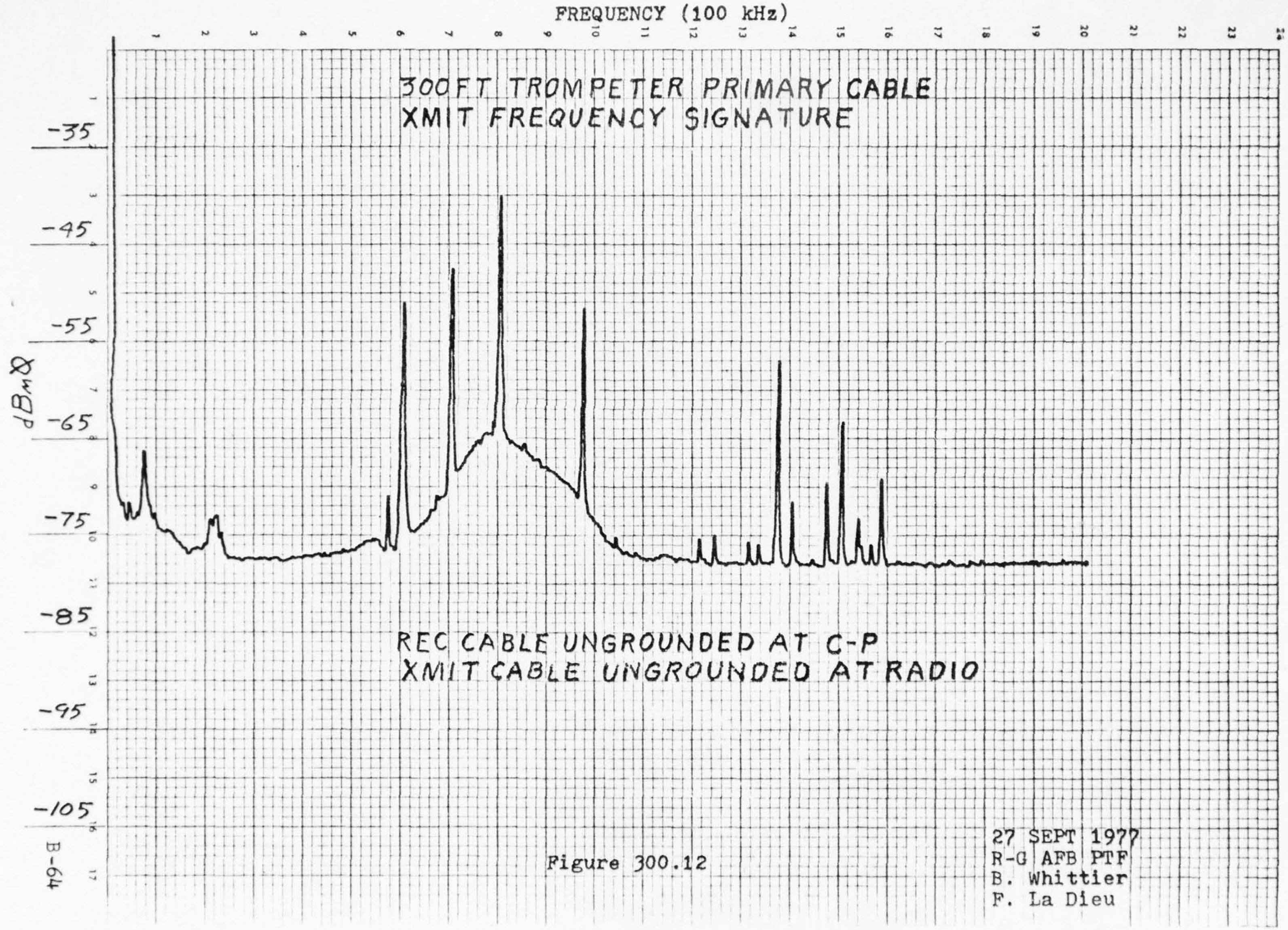


Figure 300.12

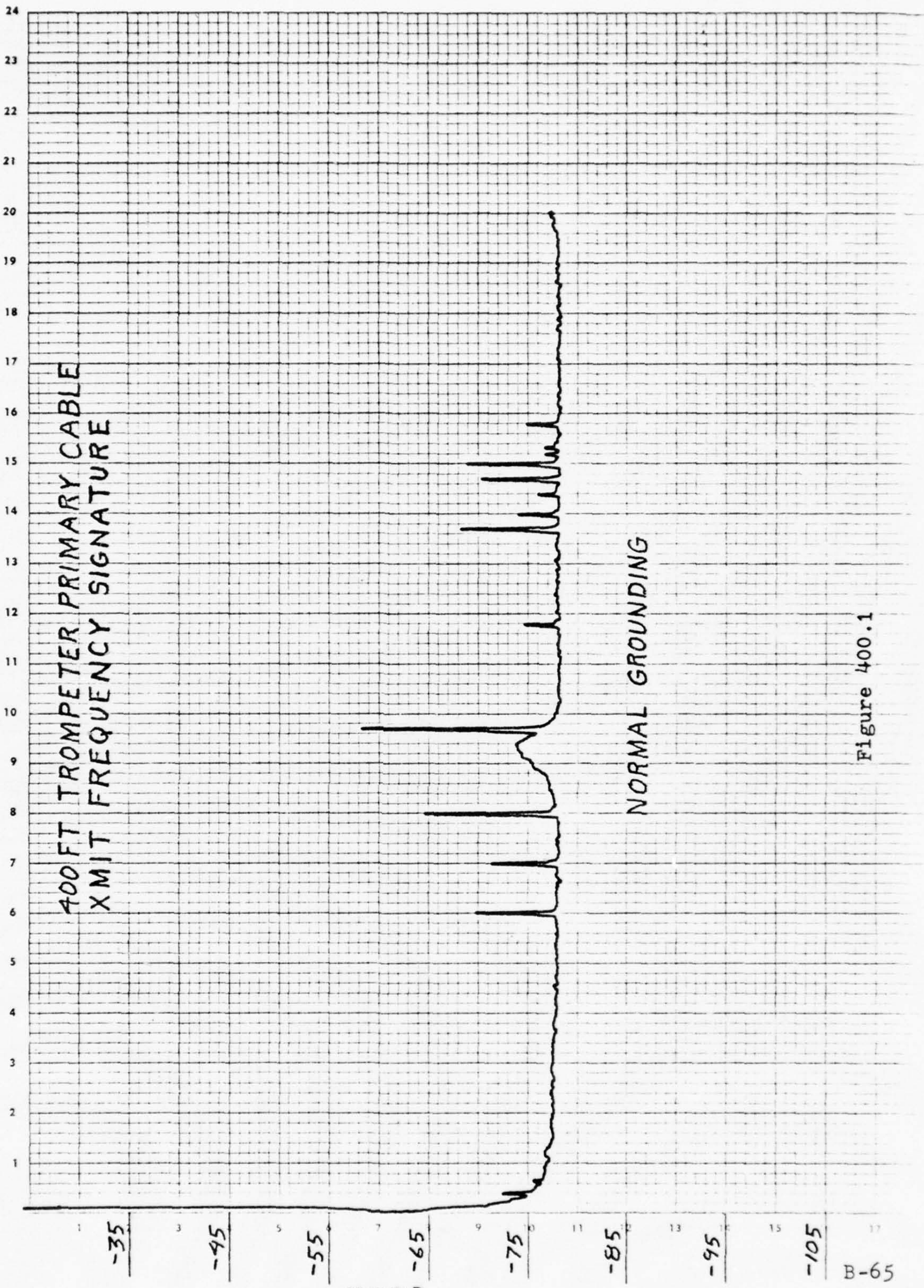

400 FT TROMPETER PRIMARY CABLE
XMIT FREQUENCY SIGNATURE
NORMAL GROUNDING
dBmØ
-35
-45
-55
-65
-75
-85
-95
-105
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Figure 400.1

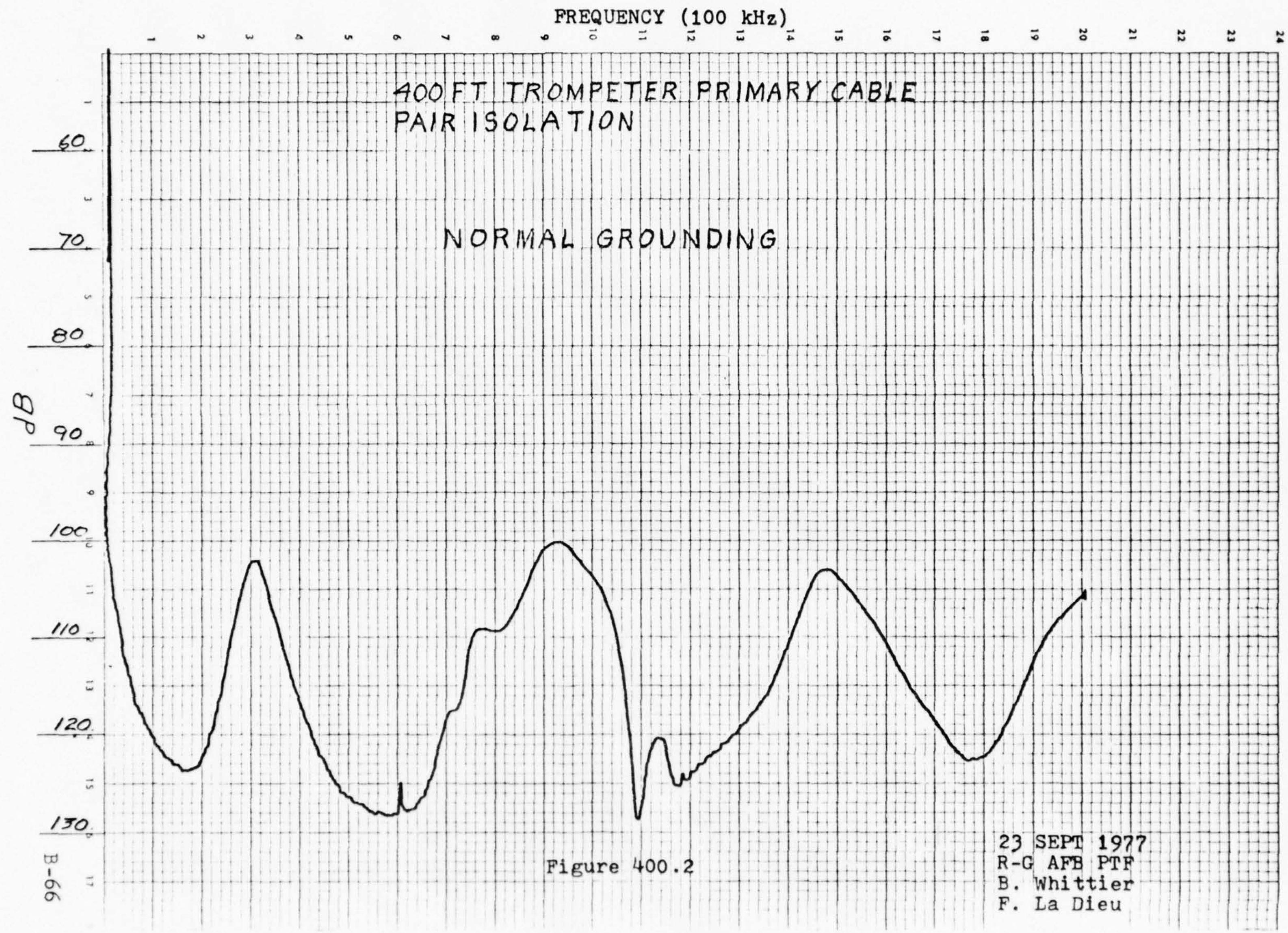
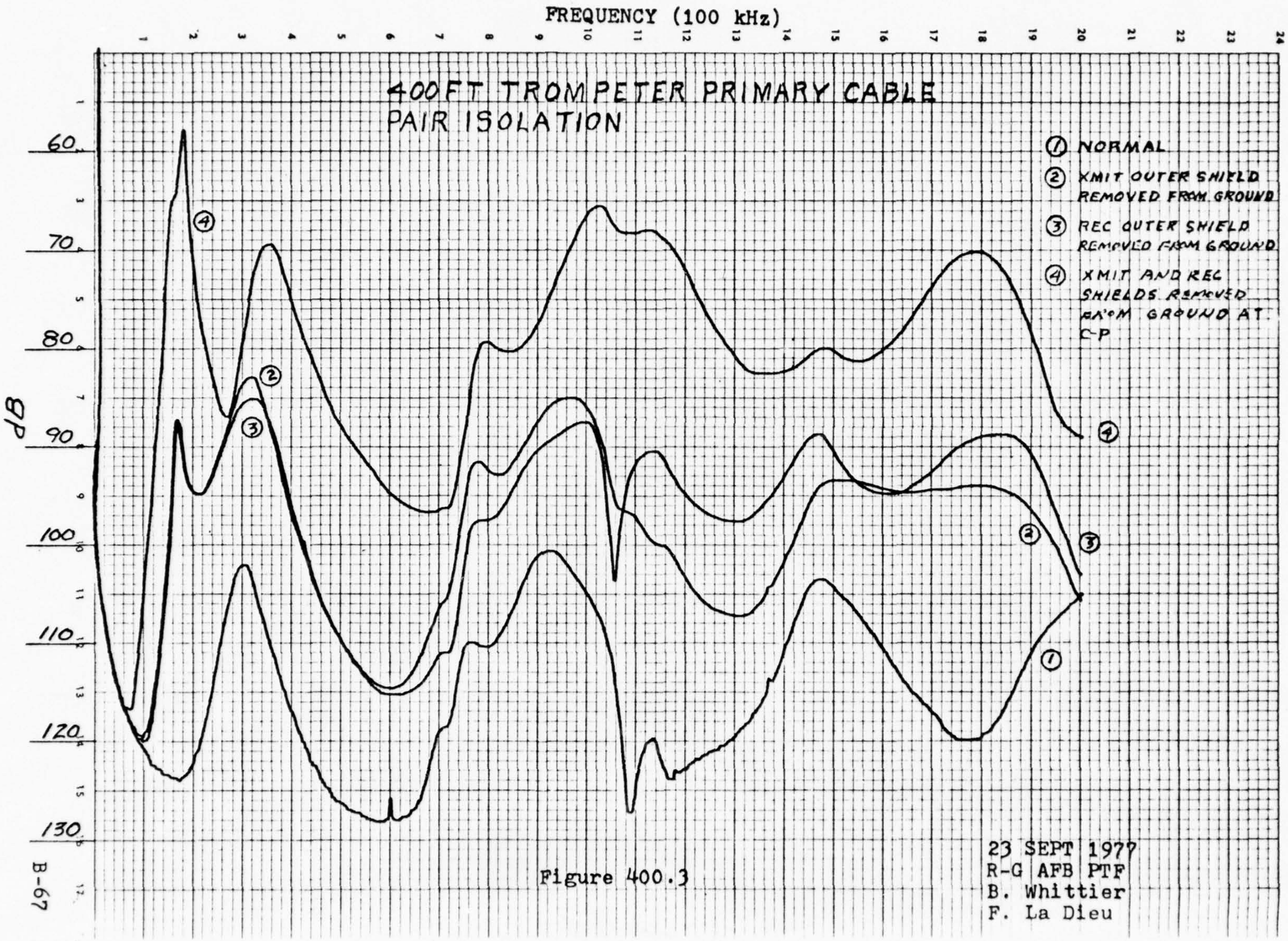
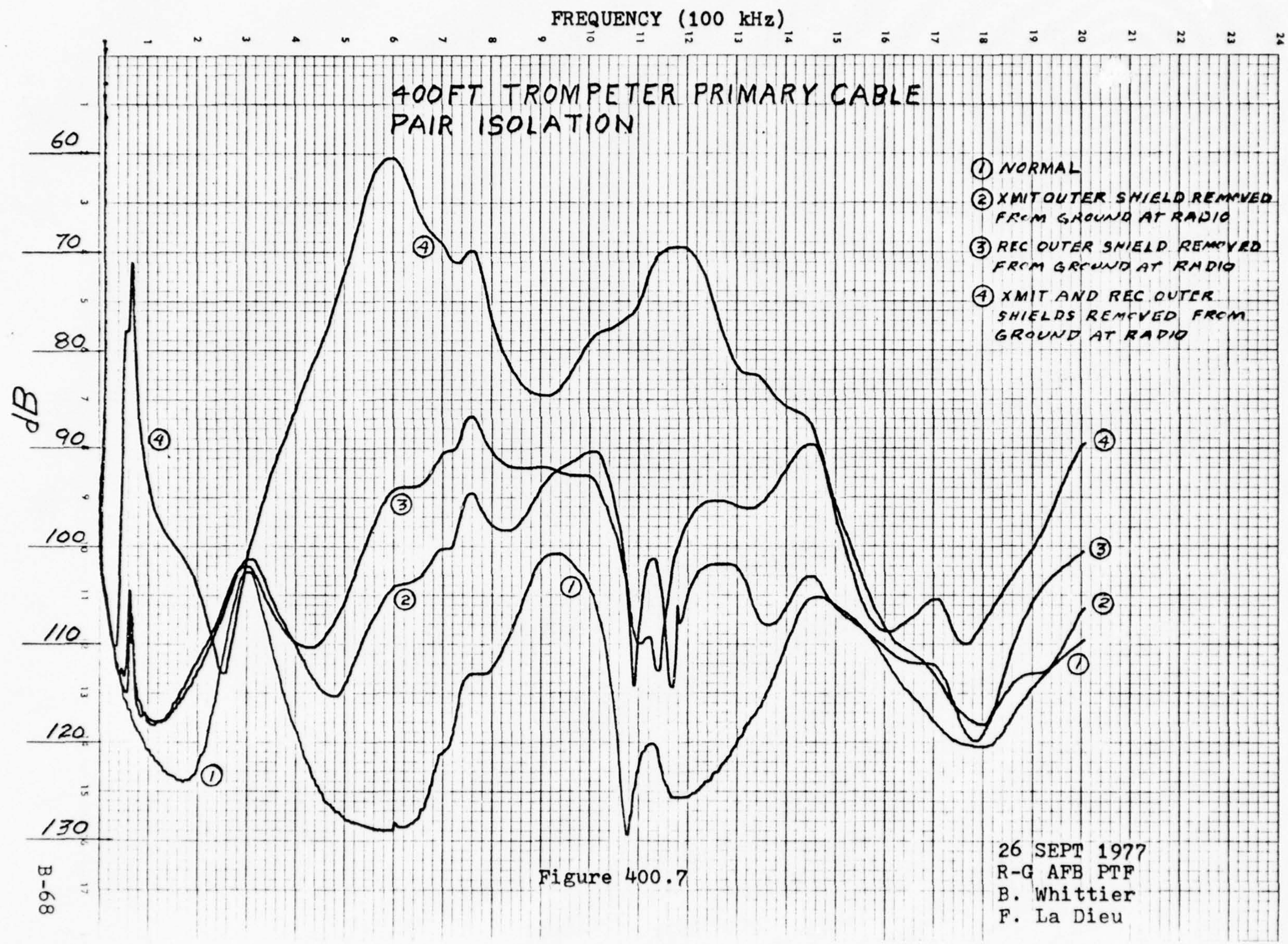

FREQUENCY (100 kHz)
400 FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
NORMAL GROUNDING
dB
60
70
80
90
100
110
120
130
23 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 400.2



FREQUENCY (100 kHz)
400FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
1 NORMAL
2 XMIT OUTER SHIELD REMOVED FROM GROUND
3 REC OUTER SHIELD REMOVED FROM GROUND
4 XMIT AND REC SHIELDS REMOVED FROM GROUND AT C-P
dB
60
70
80
90
100
110
120
130
23 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 400.3



FREQUENCY (100 kHz)
400FT TROMPETER PRIMARY CABLE
PAIR ISOLATION
1 NORMAL
2 XMIT OUTER SHIELD REMOVED FROM GROUND AT RADIO
3 REC OUTER SHIELD REMOVED FROM GROUND AT RADIO
4 XMIT AND REC OUTER SHIELDS REMOVED FROM GROUND AT RADIO
dB
60
70
80
90
100
110
120
130
26 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 400.7

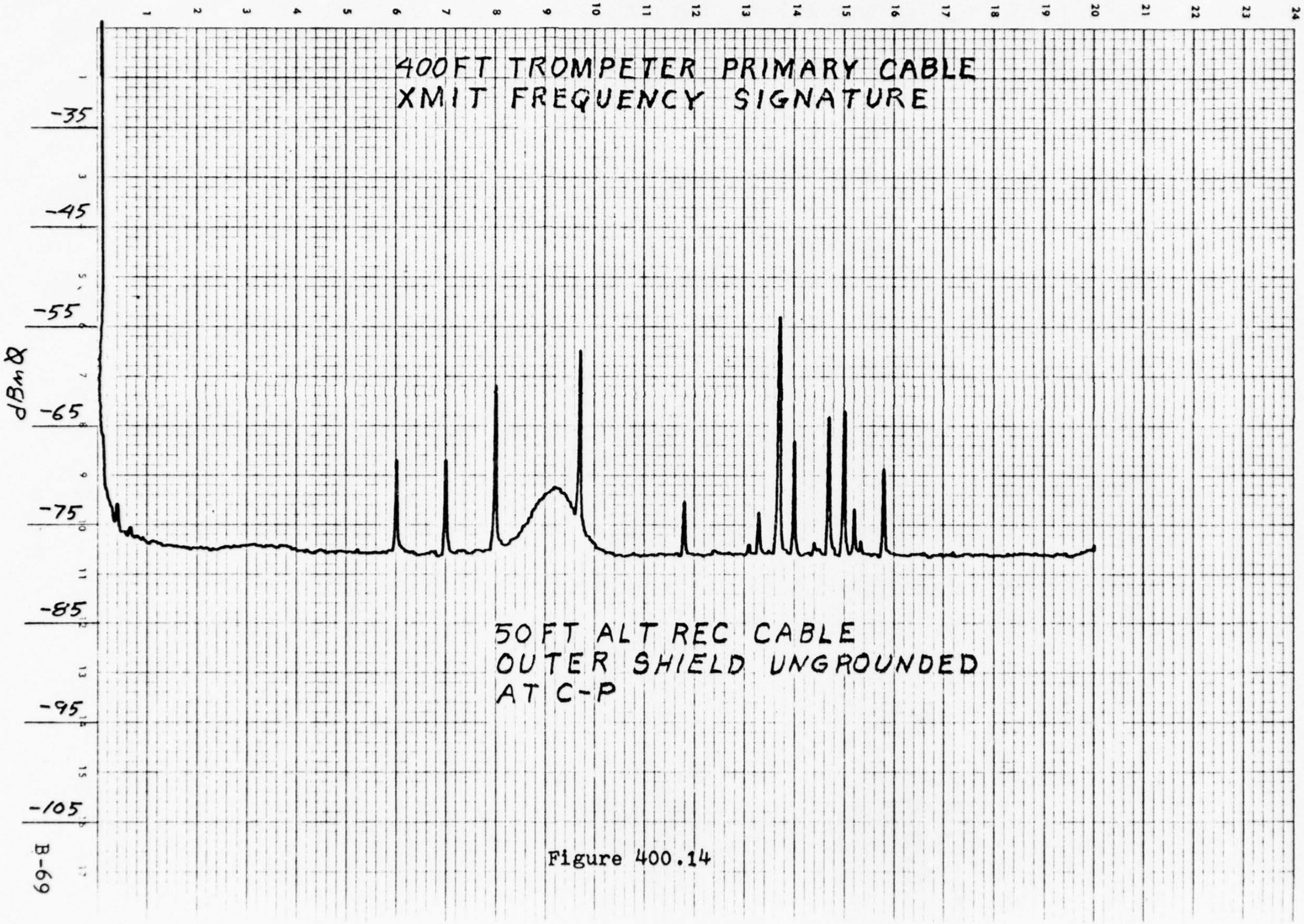


Figure 400.14

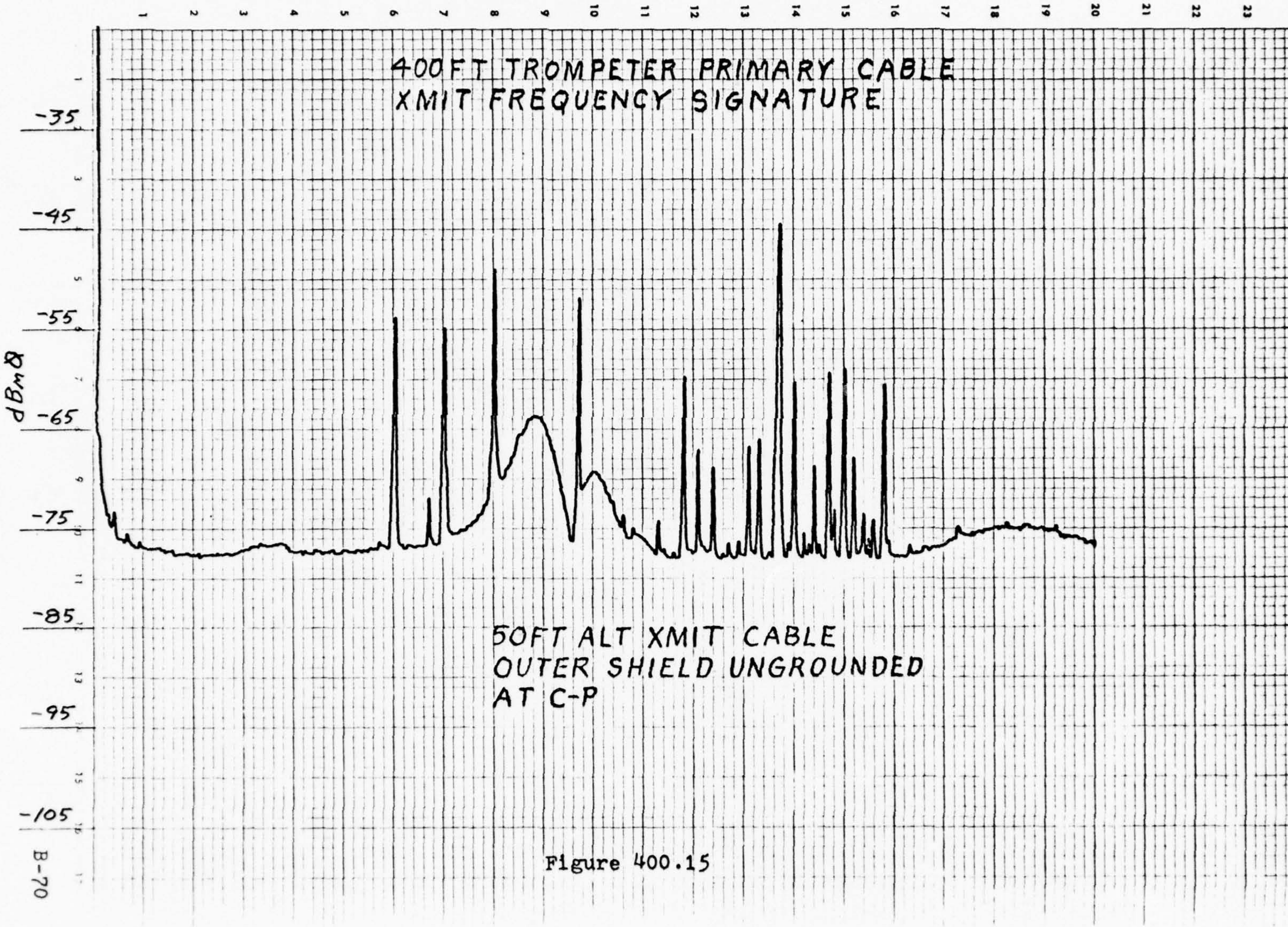


Figure 400.15

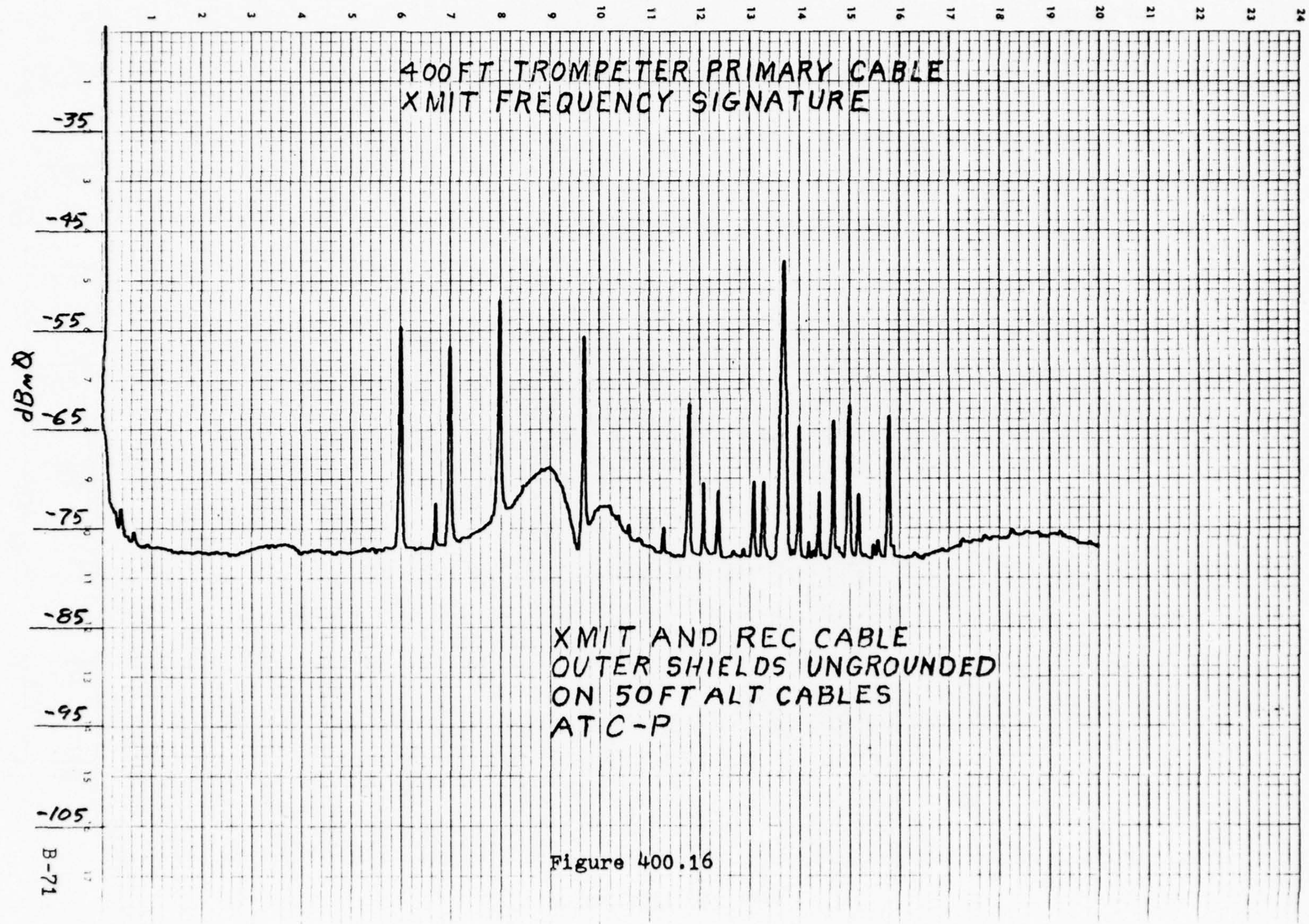


Figure 400.16

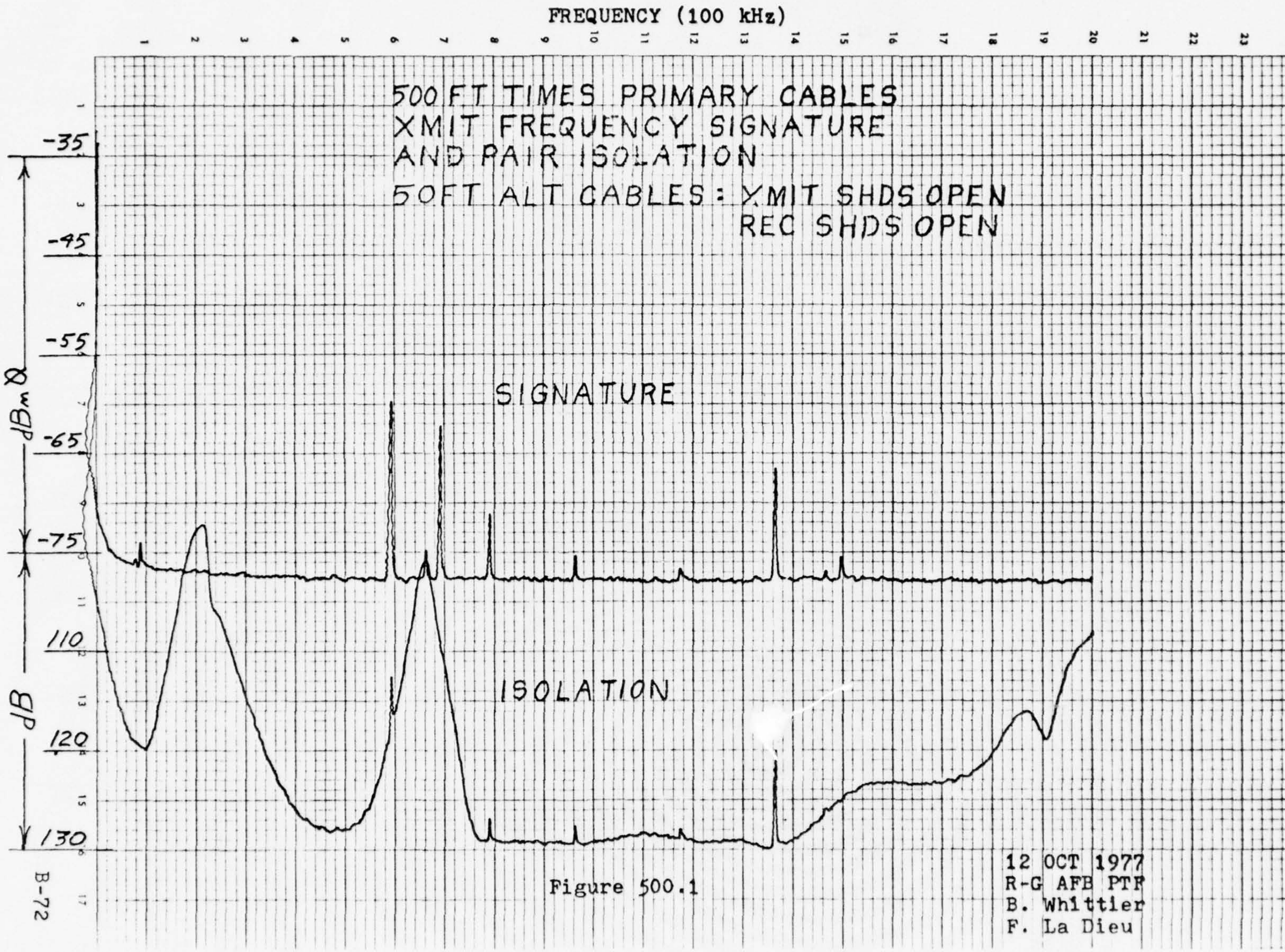


Figure 500.1

12 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

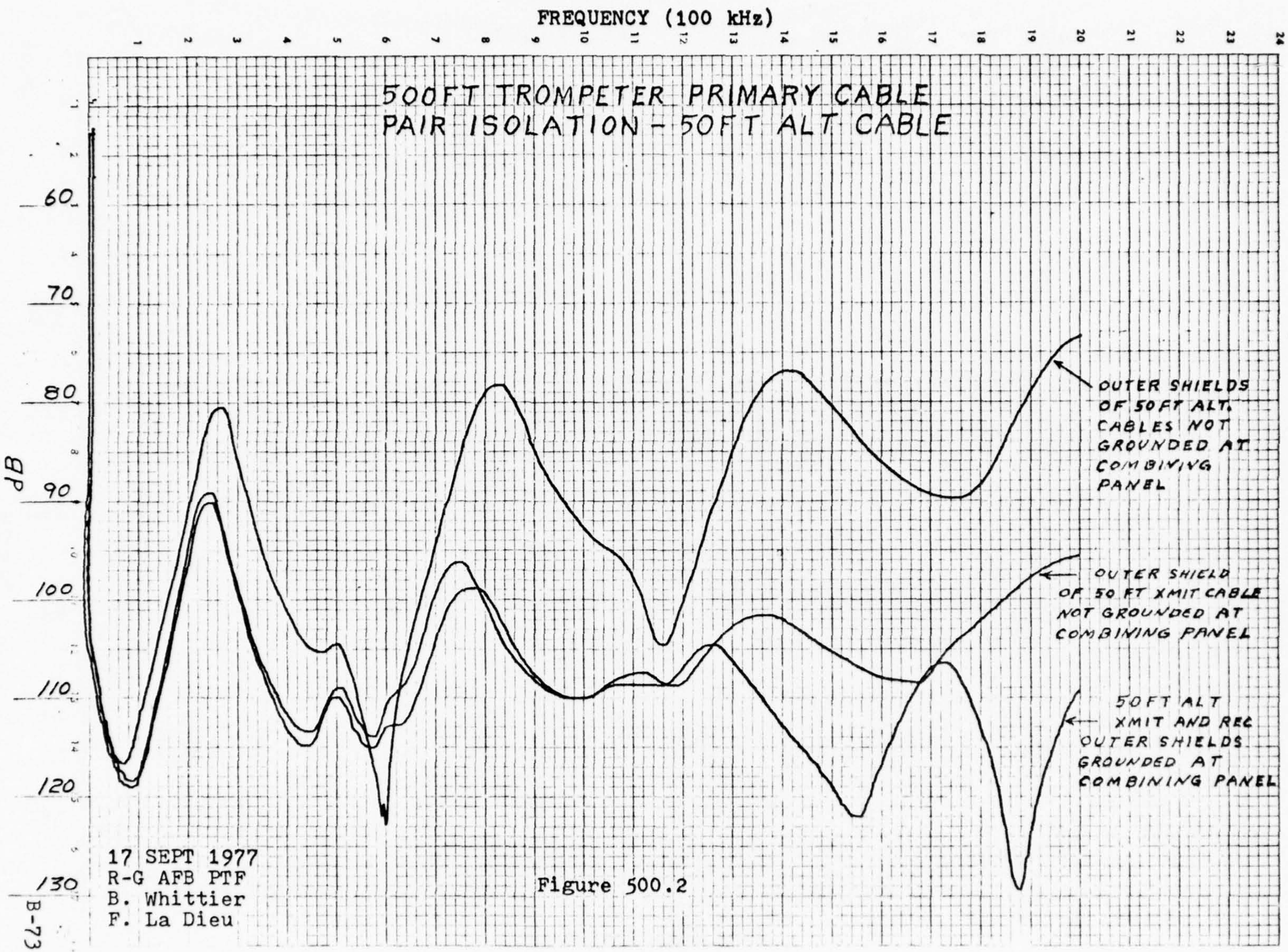

FREQUENCY (100 kHz)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
500FT TROMPETER PRIMARY CABLE
PAIR ISOLATION - 50FT ALT CABLE
dB
60
70
80
90
100
110
120
130
OUTER SHIELDS
OF 50FT ALT.
CABLES NOT
GROUNDED AT
COMBINING
PANEL
OUTER SHIELD
OF 50 FT XMIT CABLE
NOT GROUNDED AT
COMBINING PANEL
50FT ALT
XMIT AND REC
OUTER SHIELDS
GROUNDED AT
COMBINING PANEL
17 SEPT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 500.2

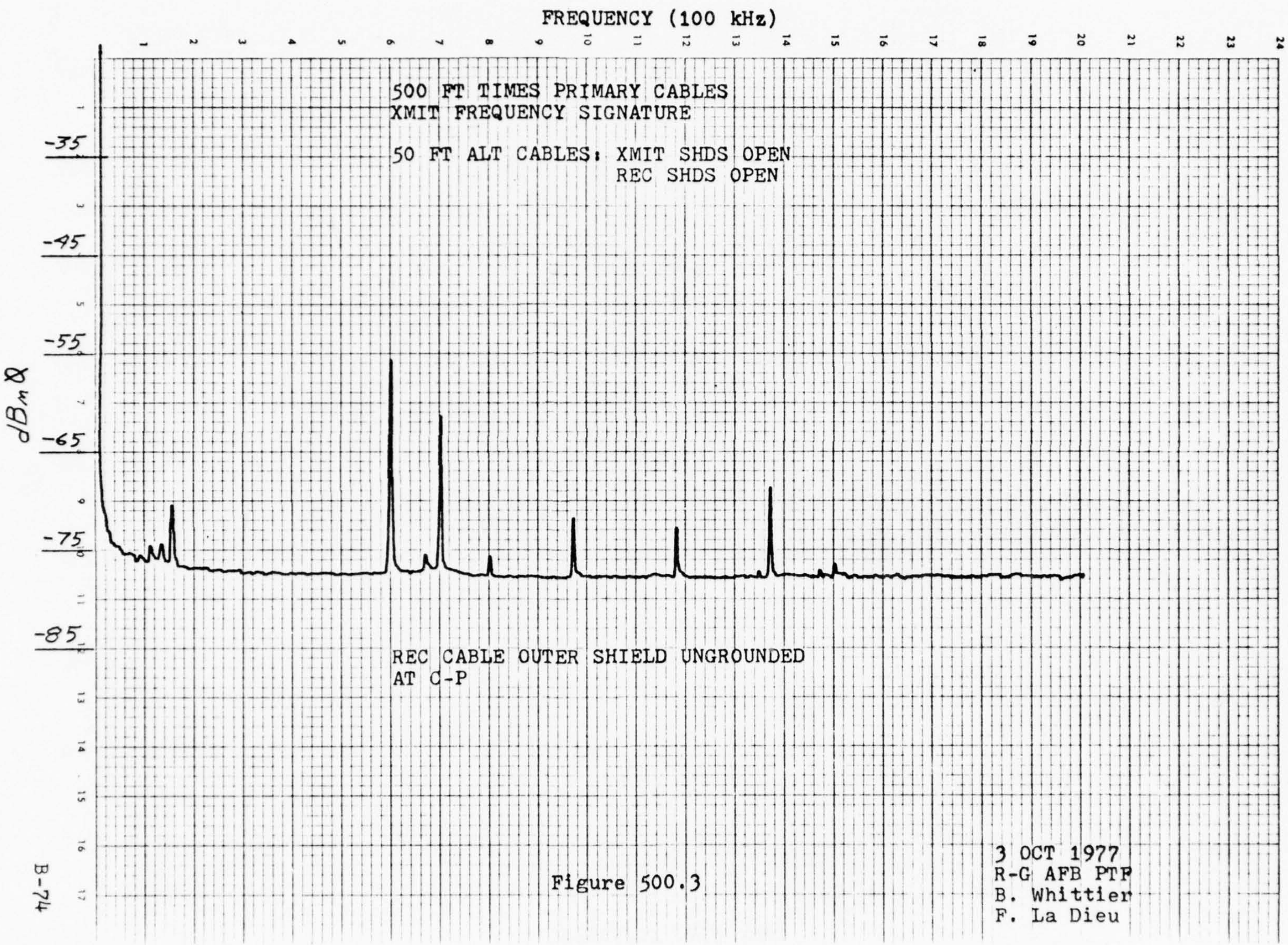

FREQUENCY (100 kHz)
500 FT TIMES PRIMARY CABLES
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
REC CABLE OUTER SHIELD UNGROUNDED
AT C-P
dBm
-35
-45
-55
-65
-75
-85
3 OCT 1977
R-G AFB PTP
B. Whittier
F. La Dieu

Figure 500.3

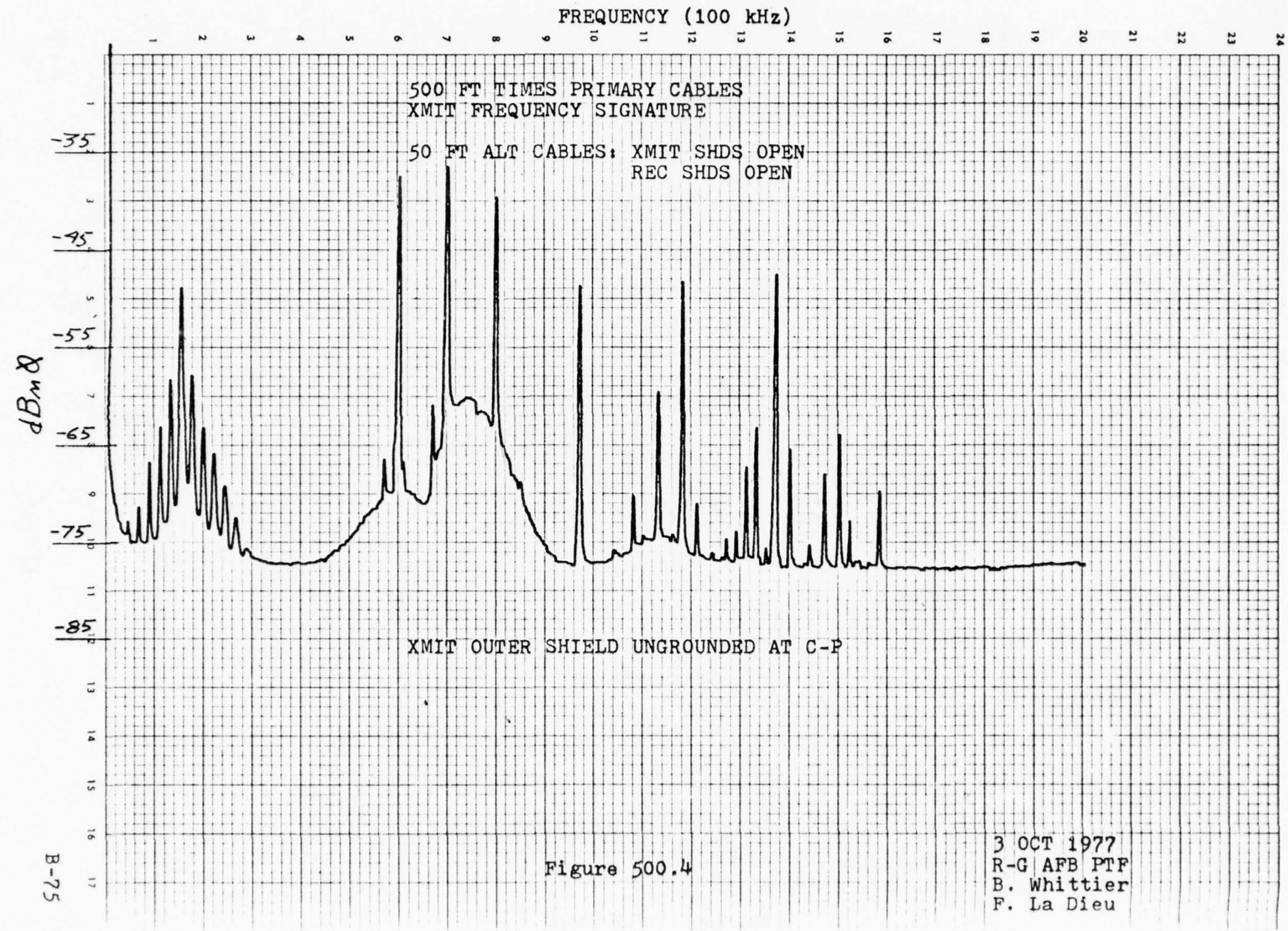

FREQUENCY (100 kHz)
500 FT TIMES PRIMARY CABLES
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
XMIT OUTER SHIELD UNGROUNDED AT C-P
dBm
-35
-45
-55
-65
-75
-85
3 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 500.4

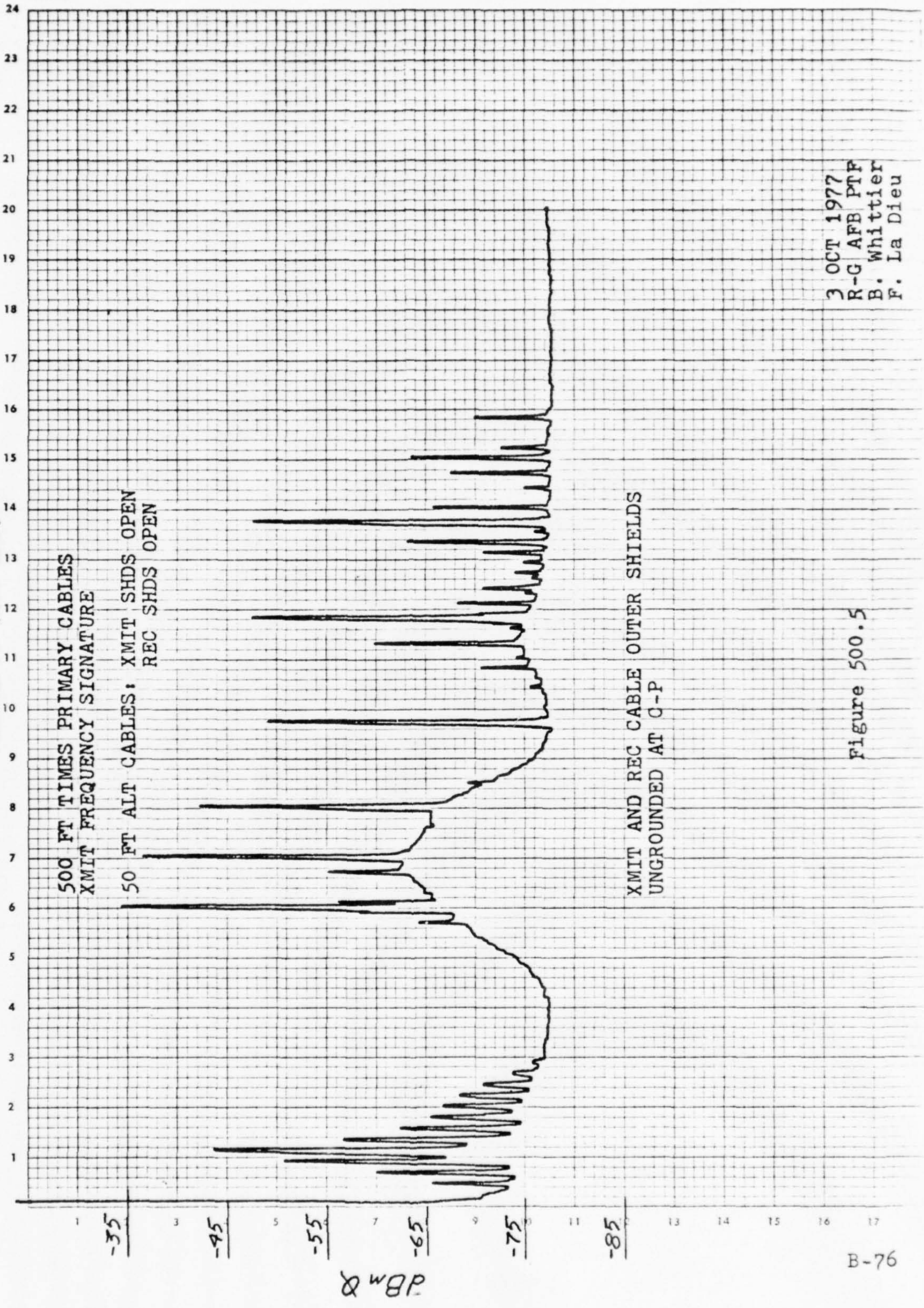
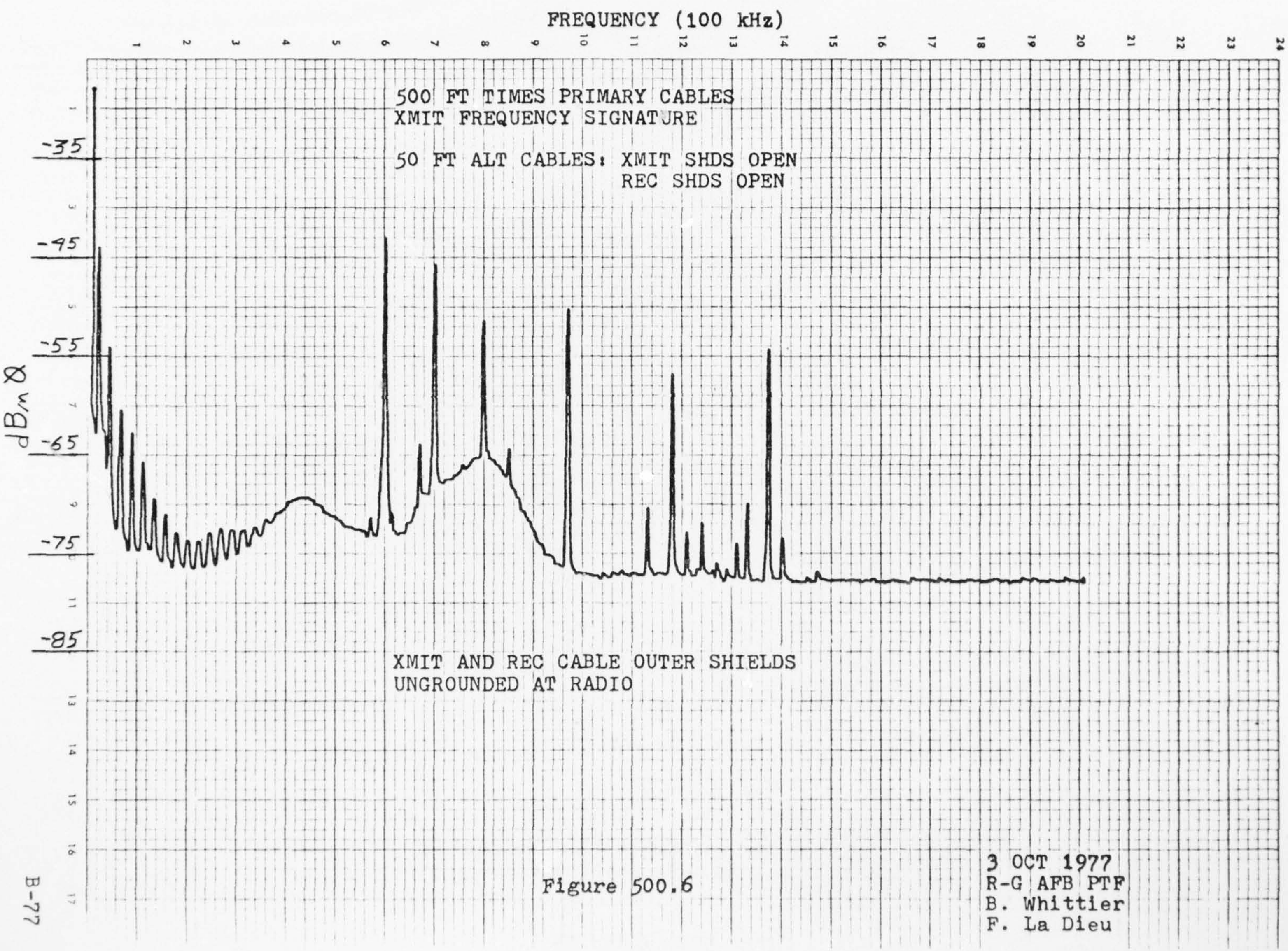
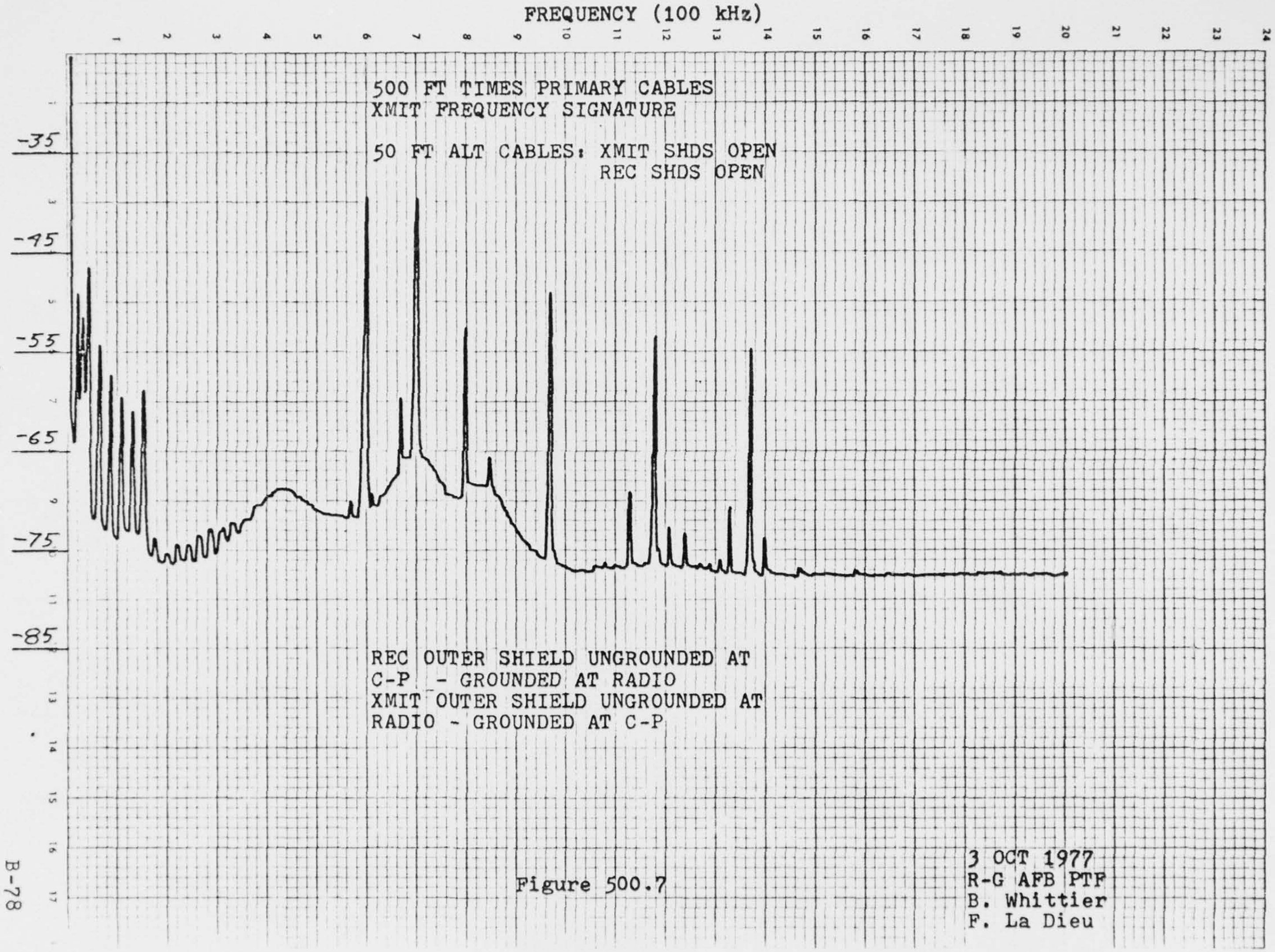

FREQUENCY (100 kHz)
500 FT TIMES PRIMARY CABLES
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
XMIT AND REC CABLE OUTER SHIELDS
UNGROUNDED AT C-P
3 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu
dBm Ω
-35
-45
-55
-65
-75
-85

Figure 500.5



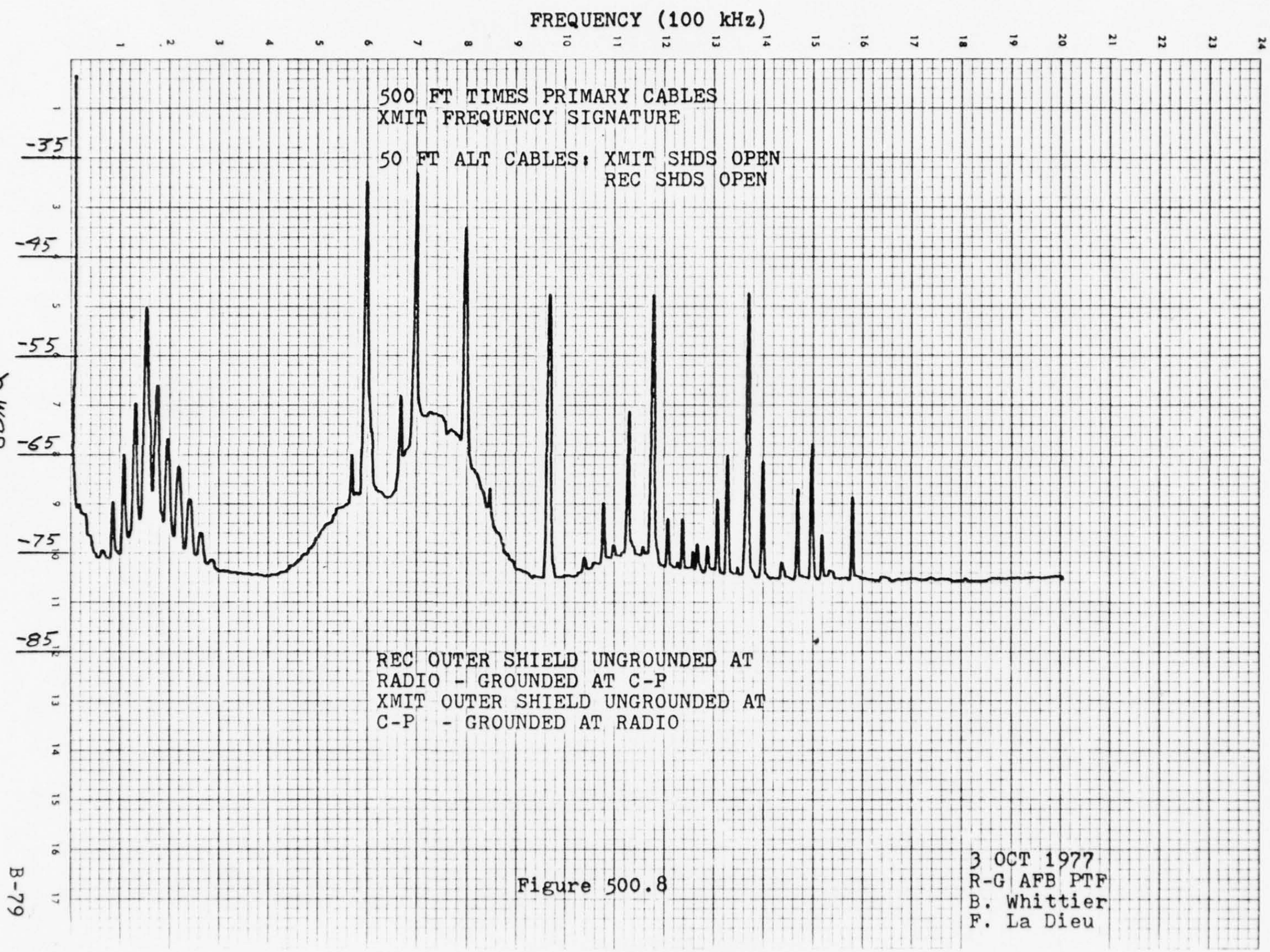
FREQUENCY (100 kHz)
500 FT TIMES PRIMARY CABLES
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
XMIT AND REC CABLE OUTER SHIELDS
UNGROUNDED AT RADIO
dBm Ø
-35
-45
-55
-65
-75
-85
3 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 500.6



FREQUENCY (100 kHz)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
-35
-45
-55
-65
-75
-85
dBm Ø
500 FT TIMES PRIMARY CABLES
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
REC OUTER SHIELD UNGROUNDED AT
C-P - GROUNDED AT RADIO
XMIT OUTER SHIELD UNGROUNDED AT
RADIO - GROUNDED AT C-P
3 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 500.7



FREQUENCY (100 kHz)
dBm Ø
-35
-45
-55
-65
-75
-85
500 FT TIMES PRIMARY CABLES
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
REC OUTER SHIELD UNGROUNDED AT
RADIO - GROUNDED AT C-P
XMIT OUTER SHIELD UNGROUNDED AT
C-P - GROUNDED AT RADIO
3 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 500.8

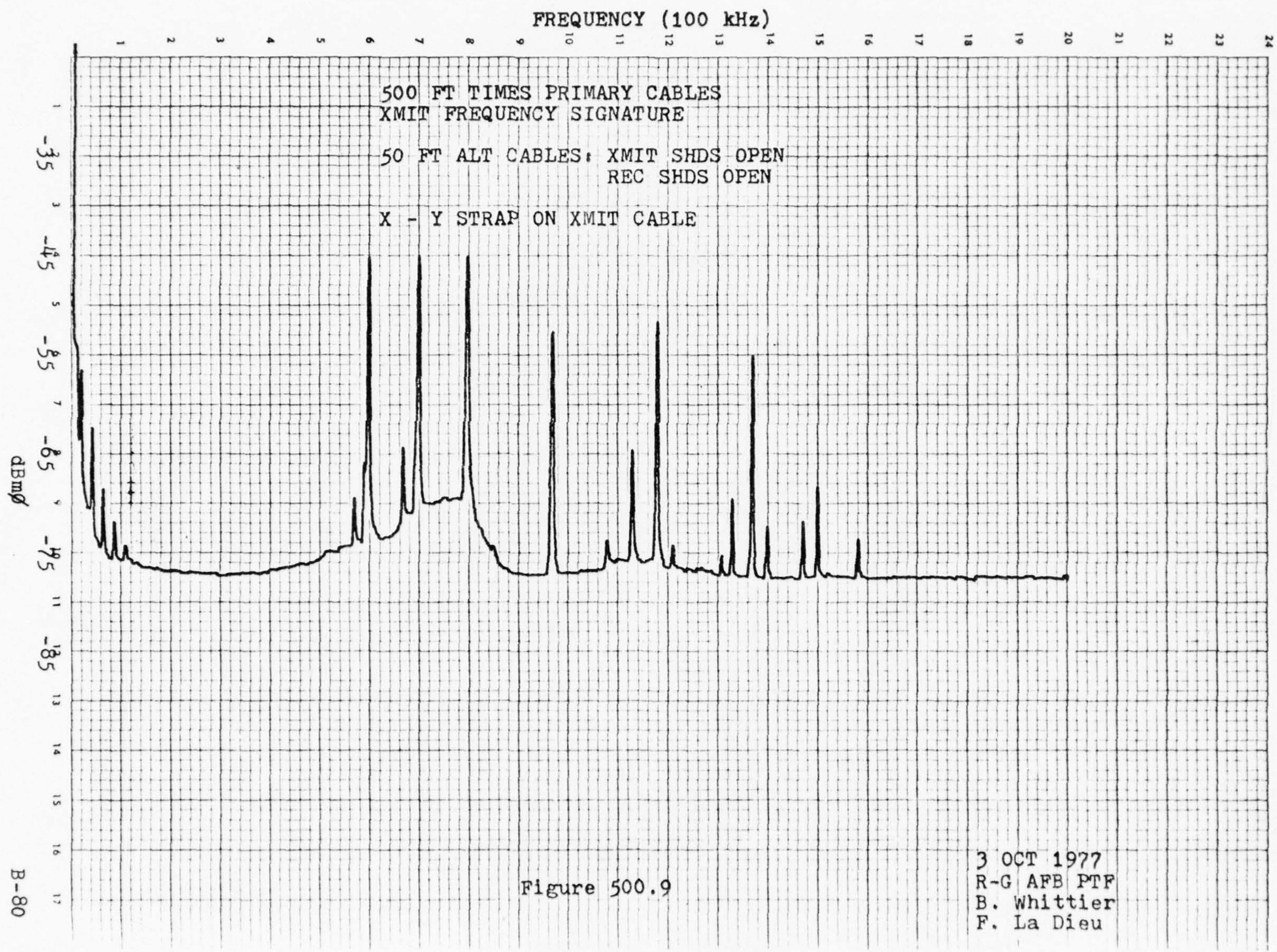

FREQUENCY (100 kHz)
500 FT TIMES PRIMARY CABLES
XMIT FREQUENCY SIGNATURE
50 FT ALT CABLES: XMIT SHDS OPEN
REC SHDS OPEN
X - Y STRAP ON XMIT CABLE
-35
-45
-55
-65
-75
-85
dBmØ
3 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 500.9

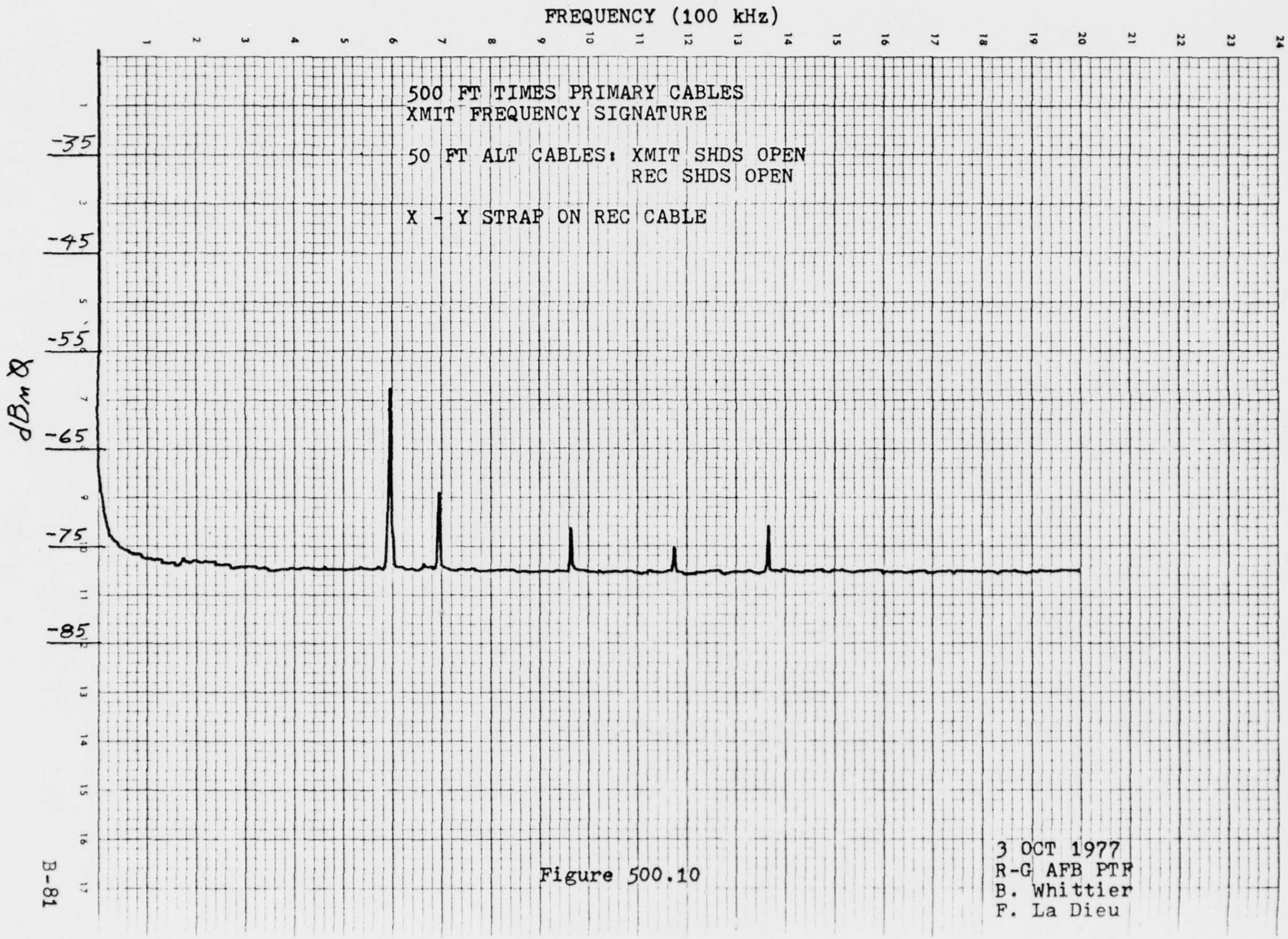


Figure 500.10

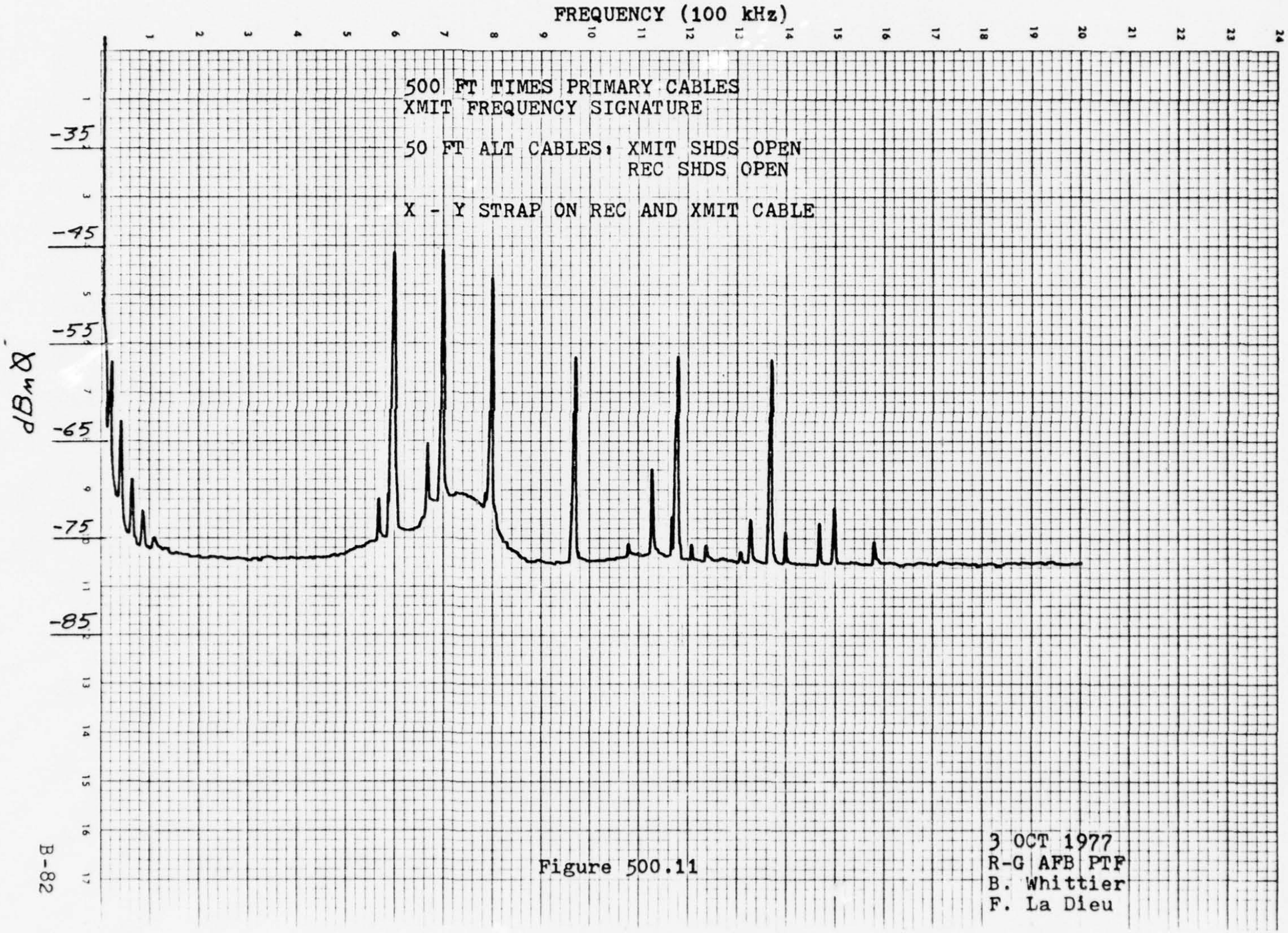


Figure 500.11

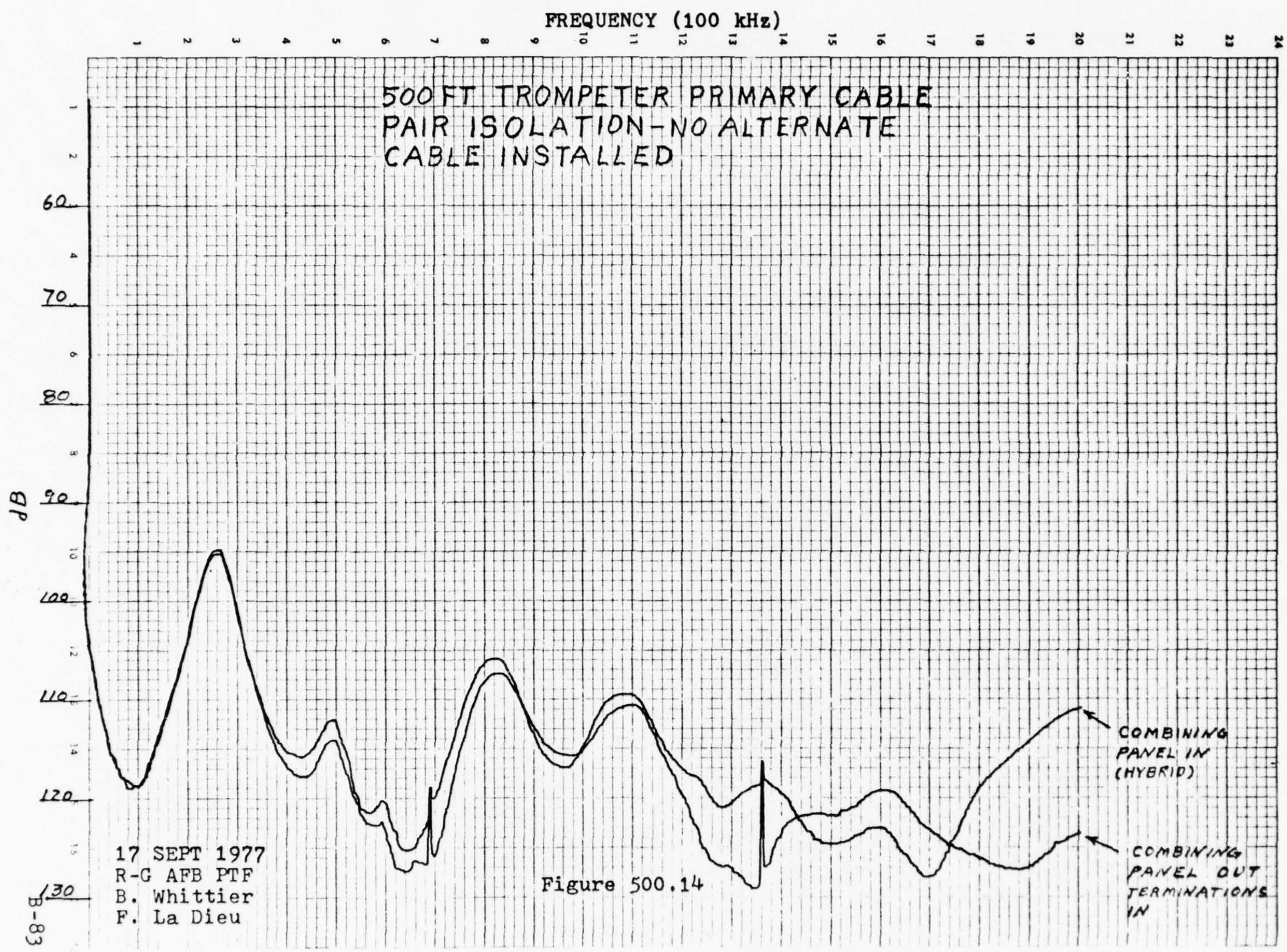


Figure 500.14

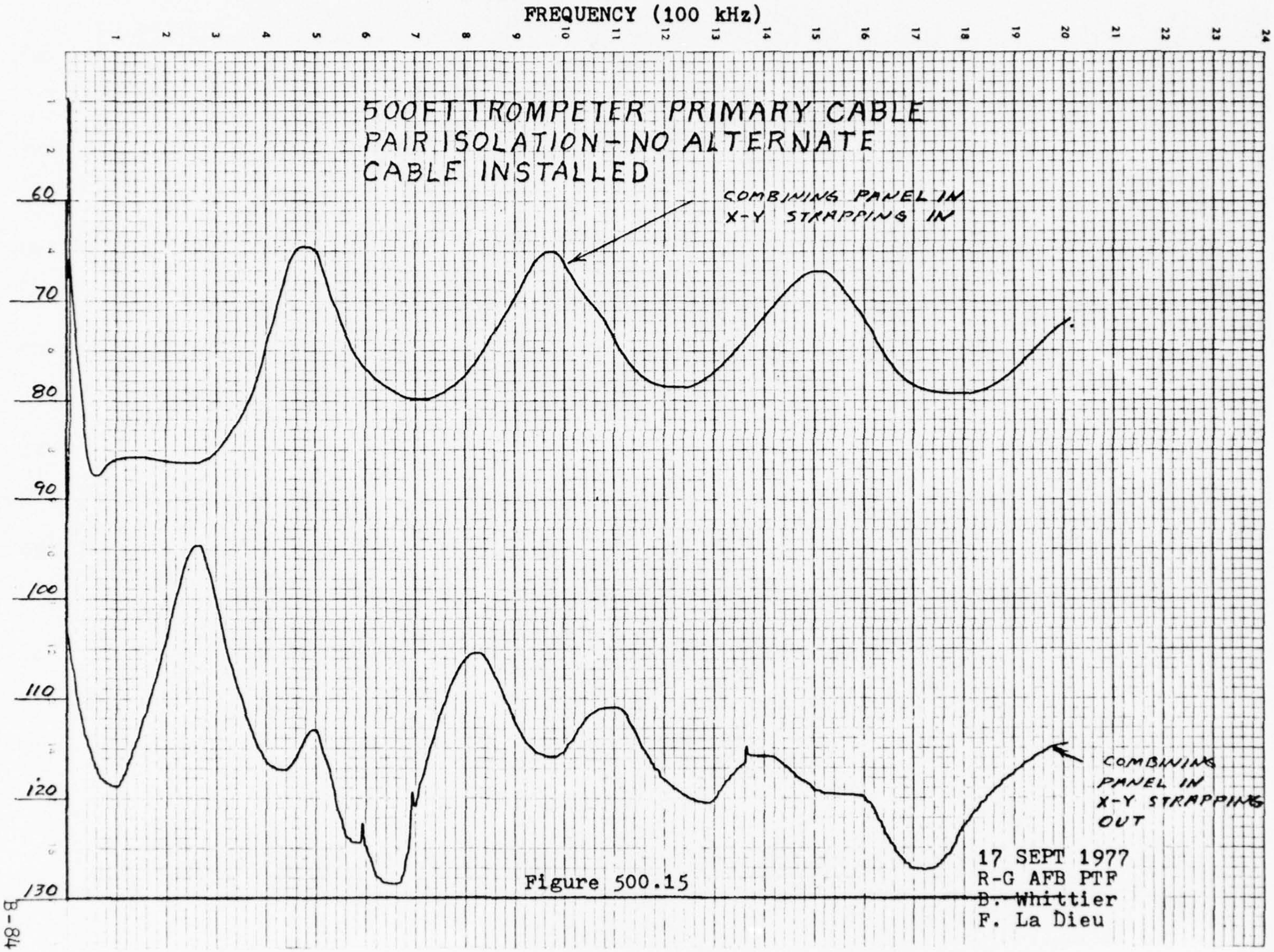


Figure 500.15

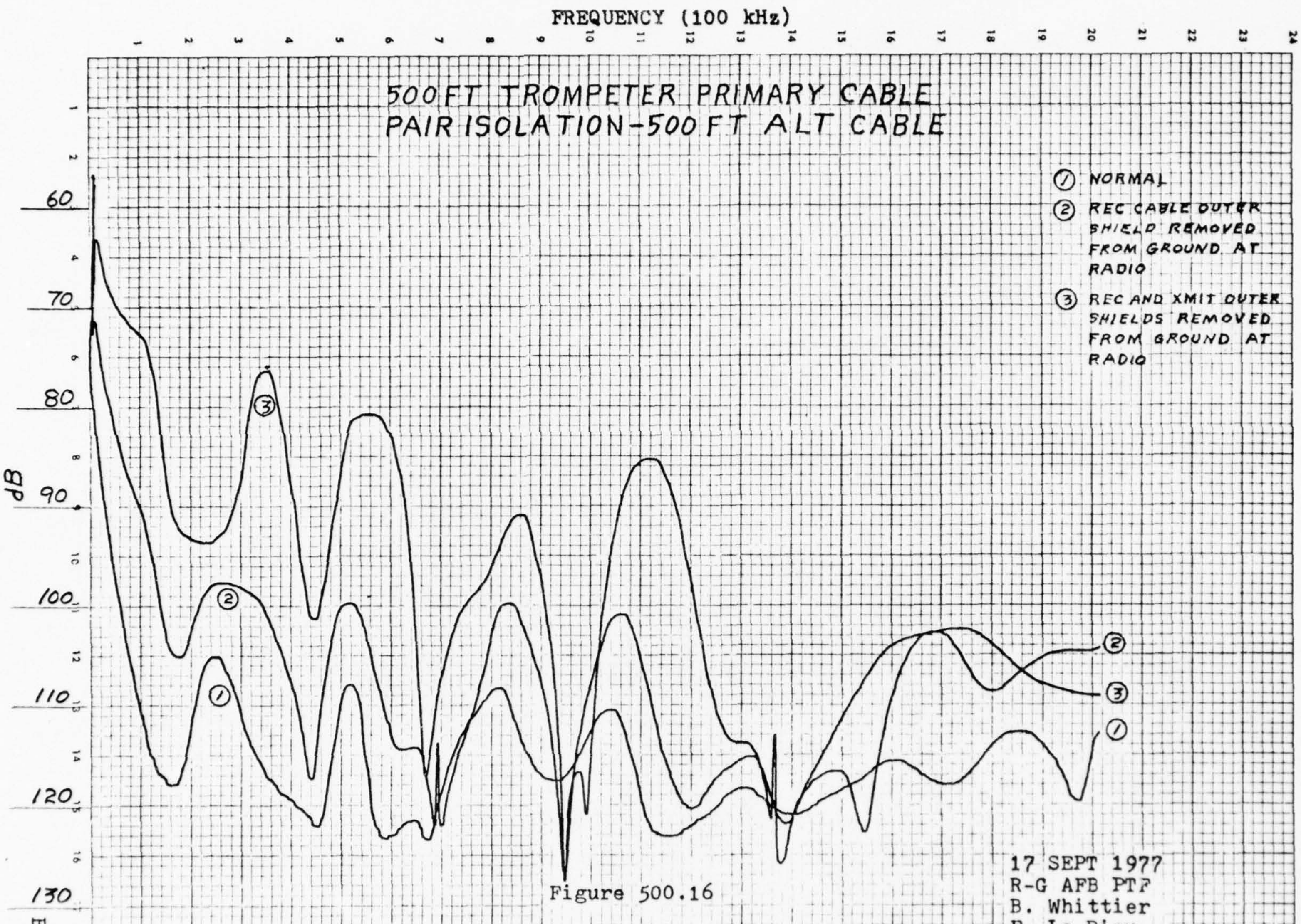


Figure 500.16

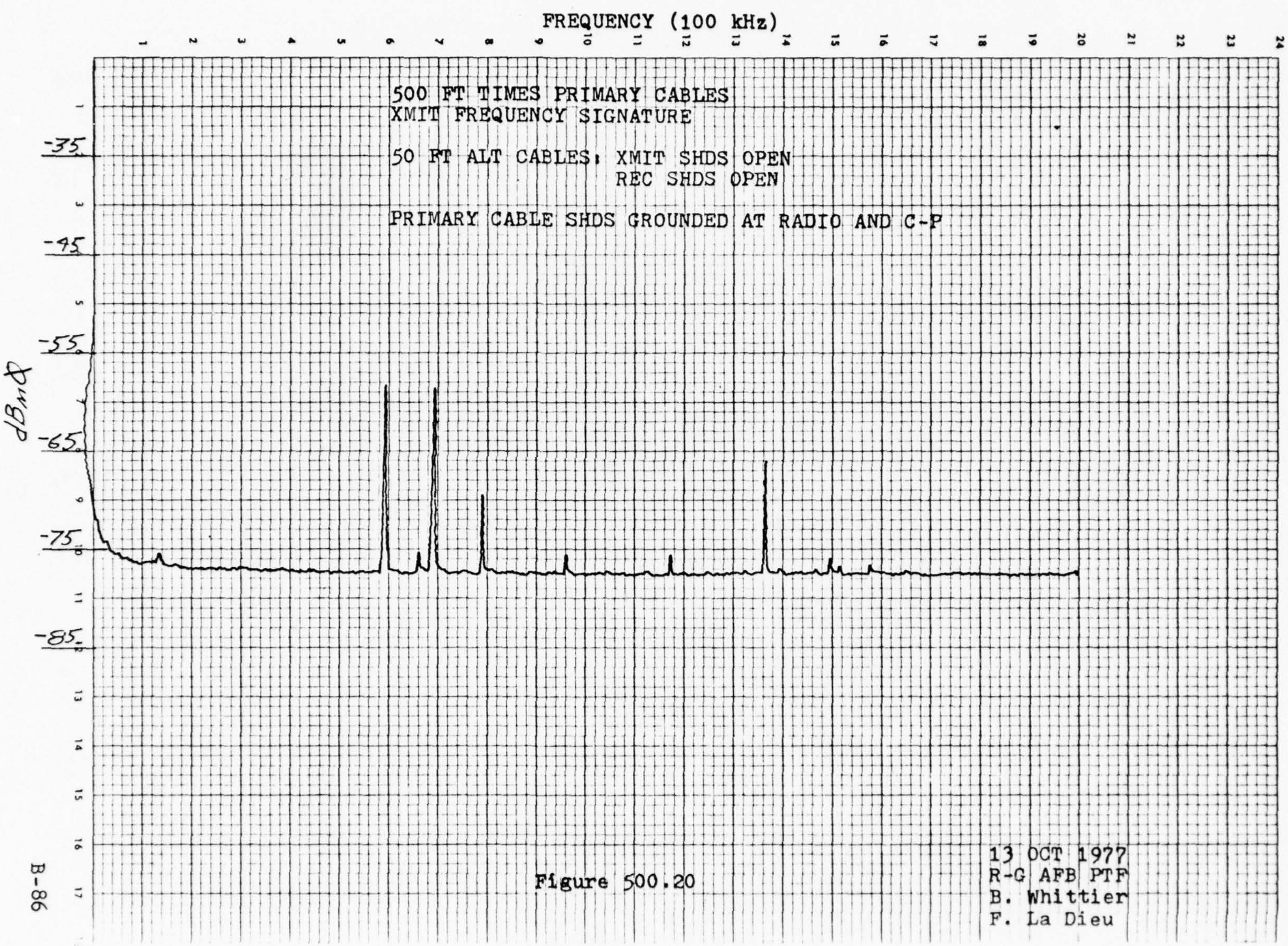


Figure 500.20

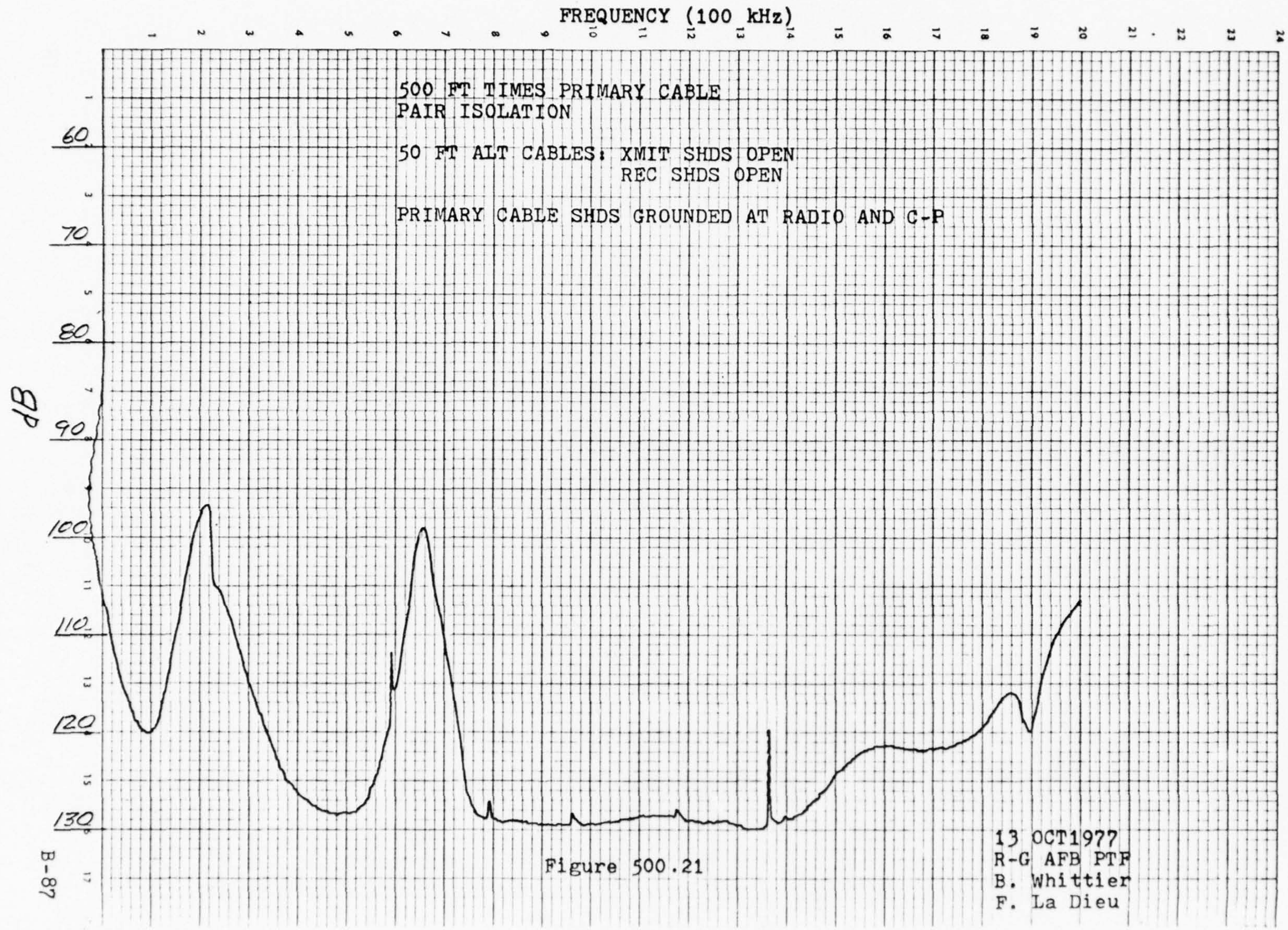


Figure 500.21

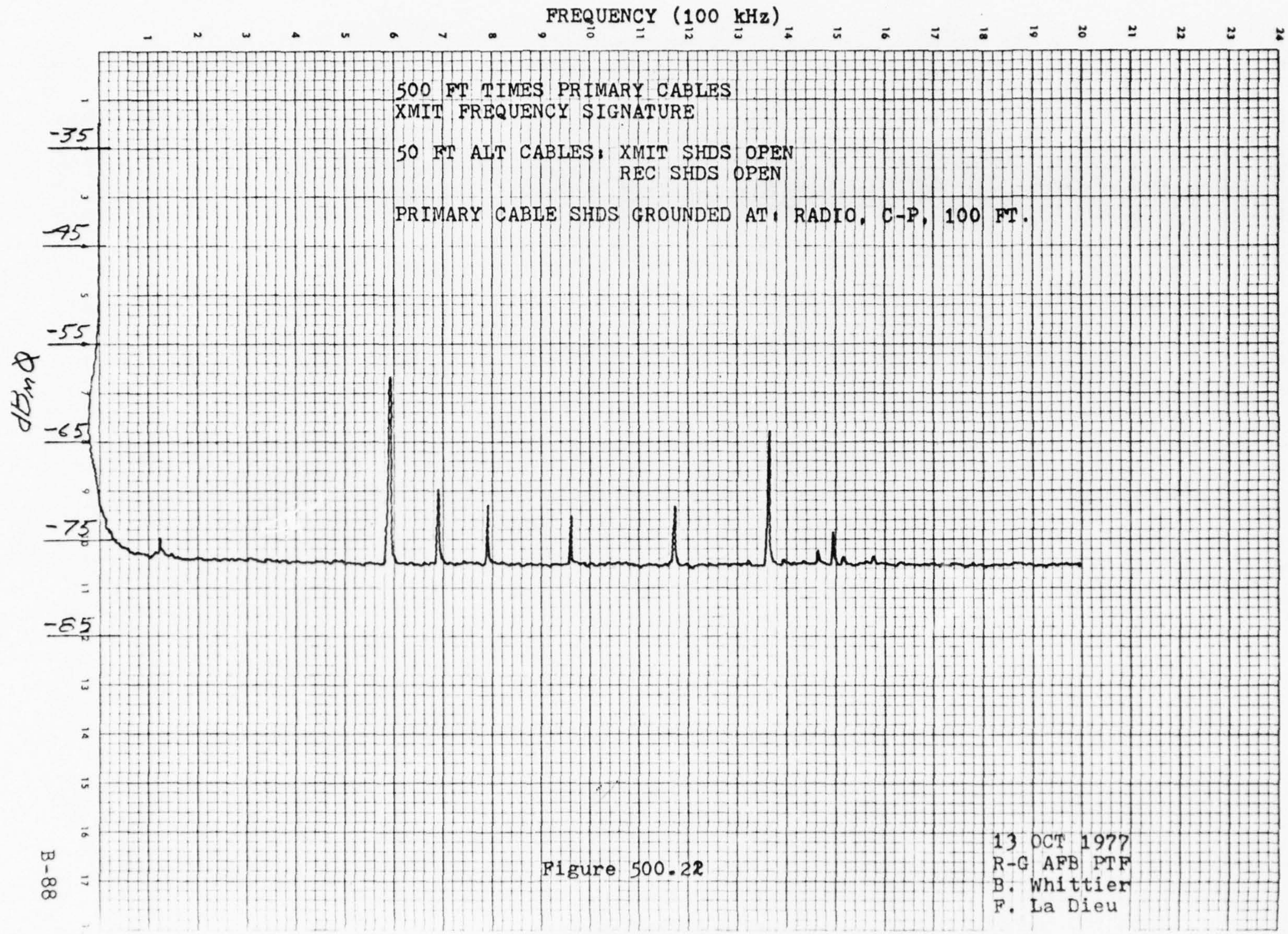


Figure 500.22

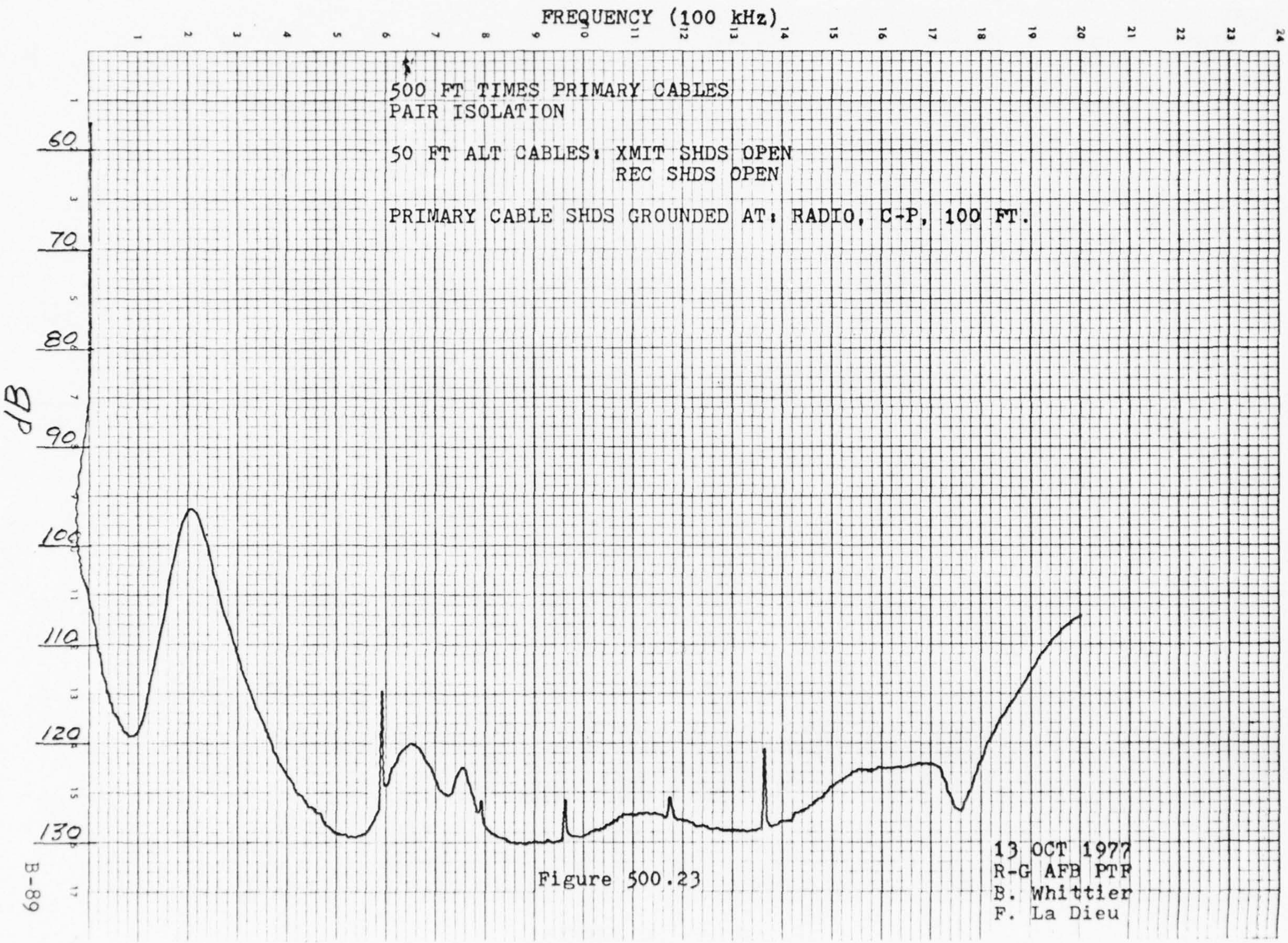


Figure 500.23

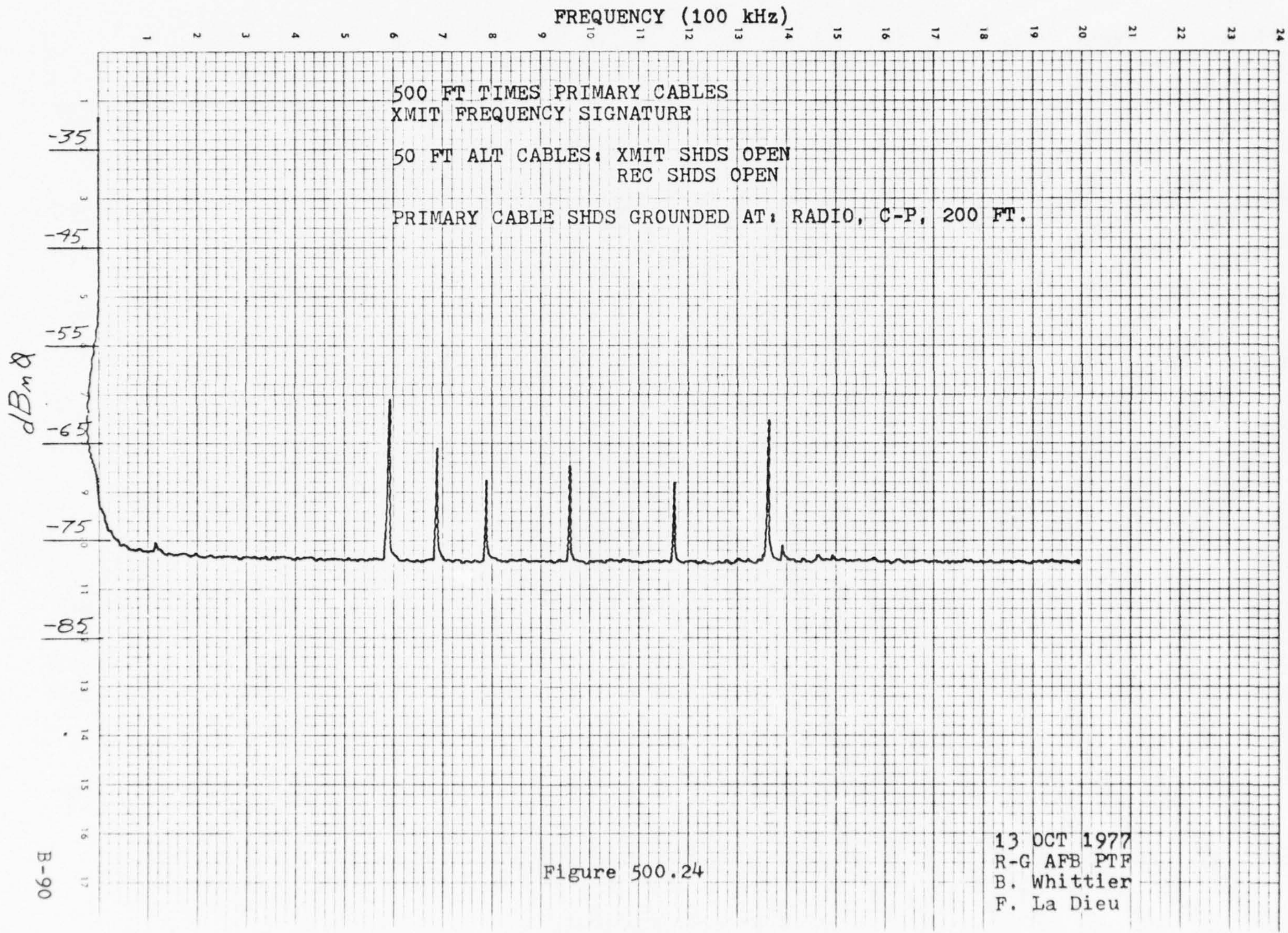


Figure 500.24

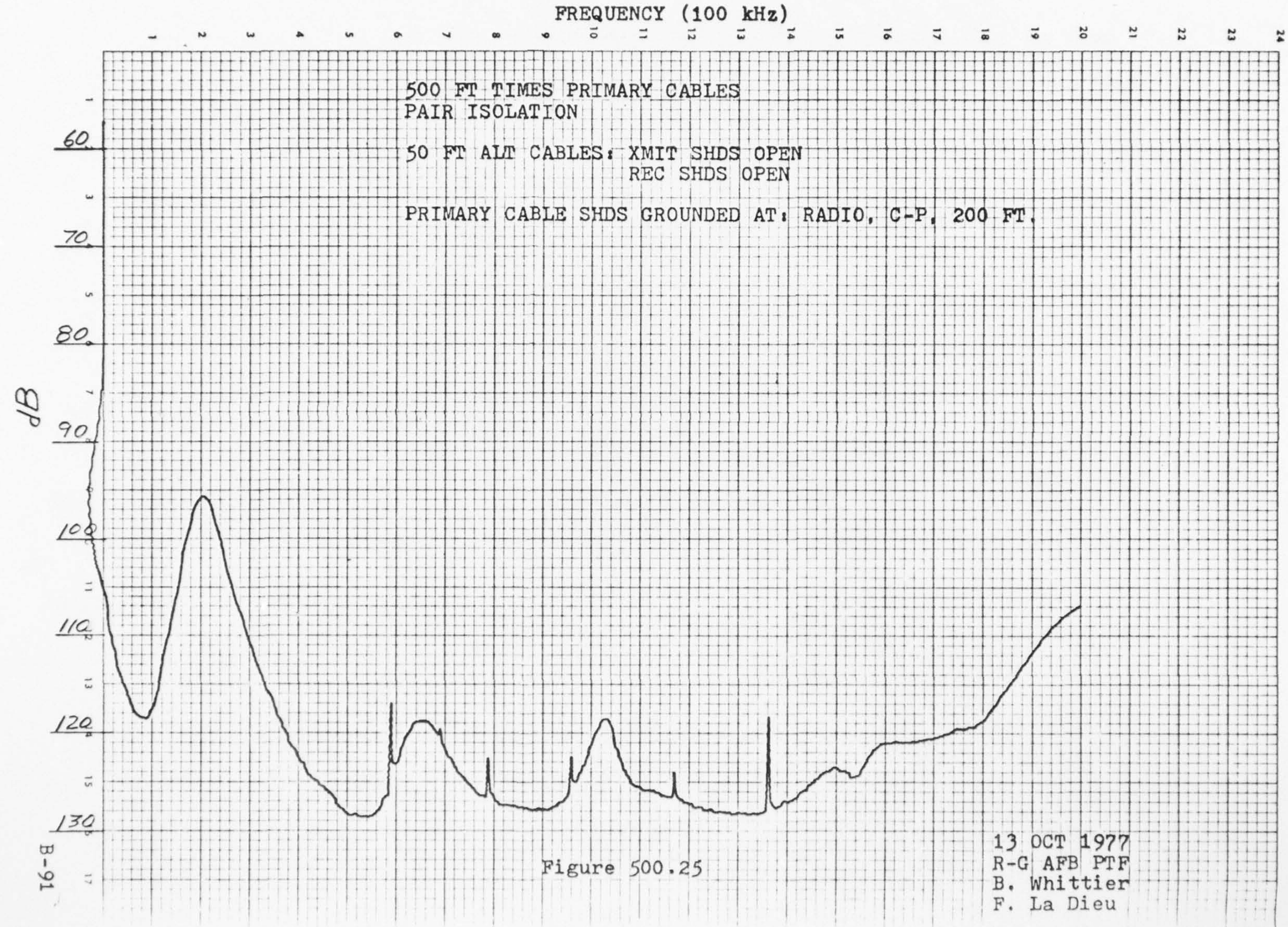


Figure 500.25

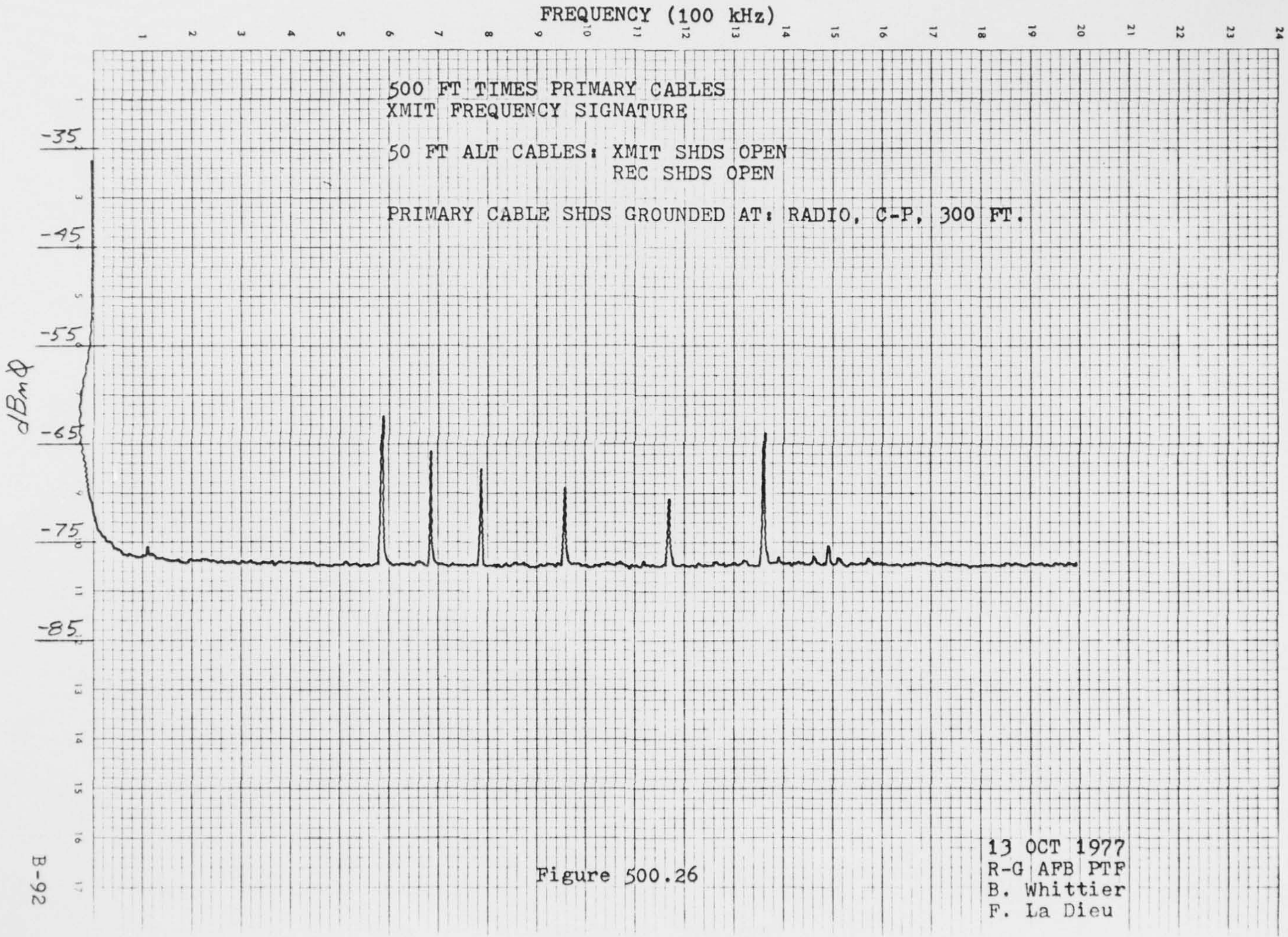


Figure 500.26

Figure 500.27

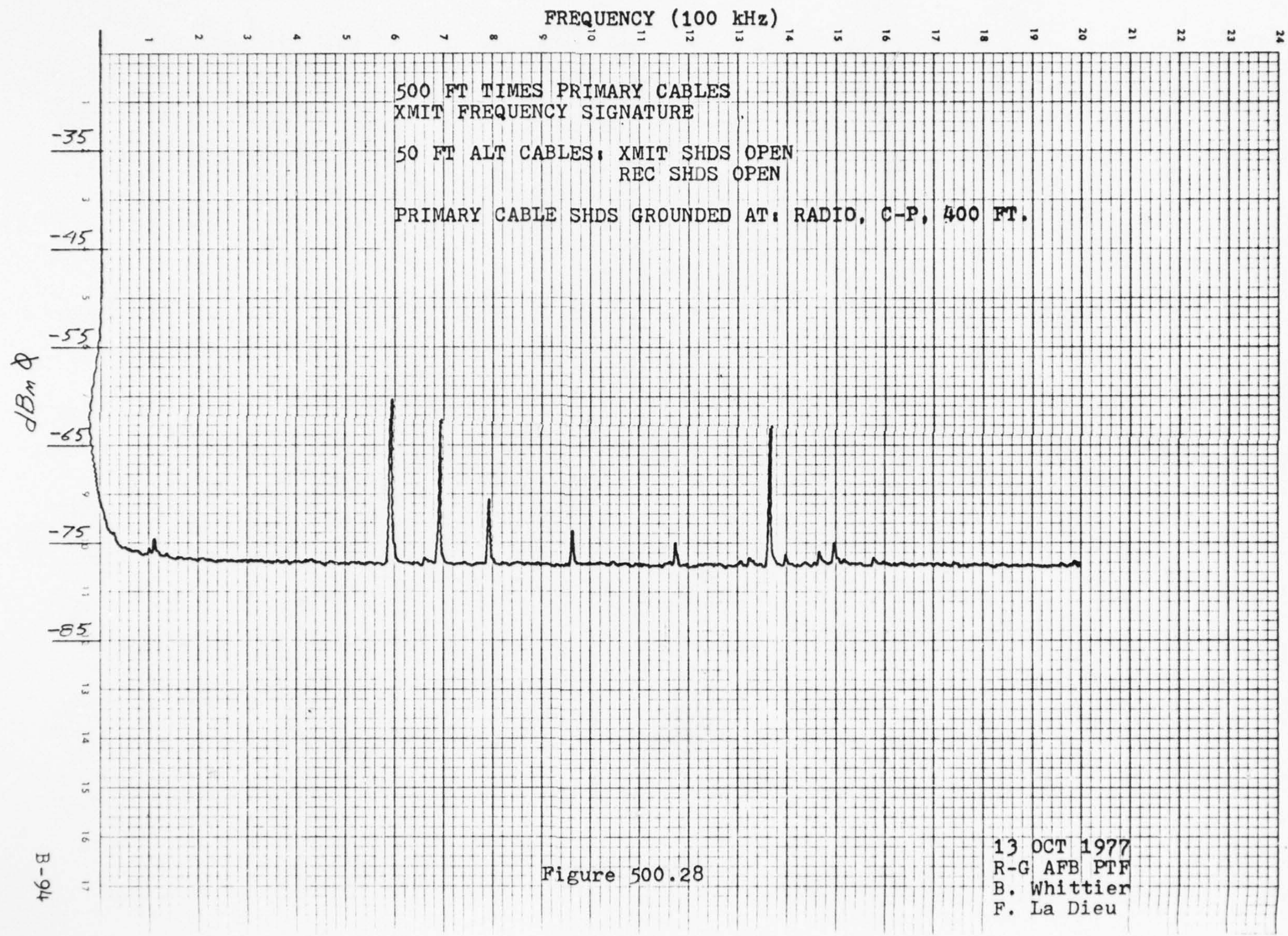


Figure 500.28

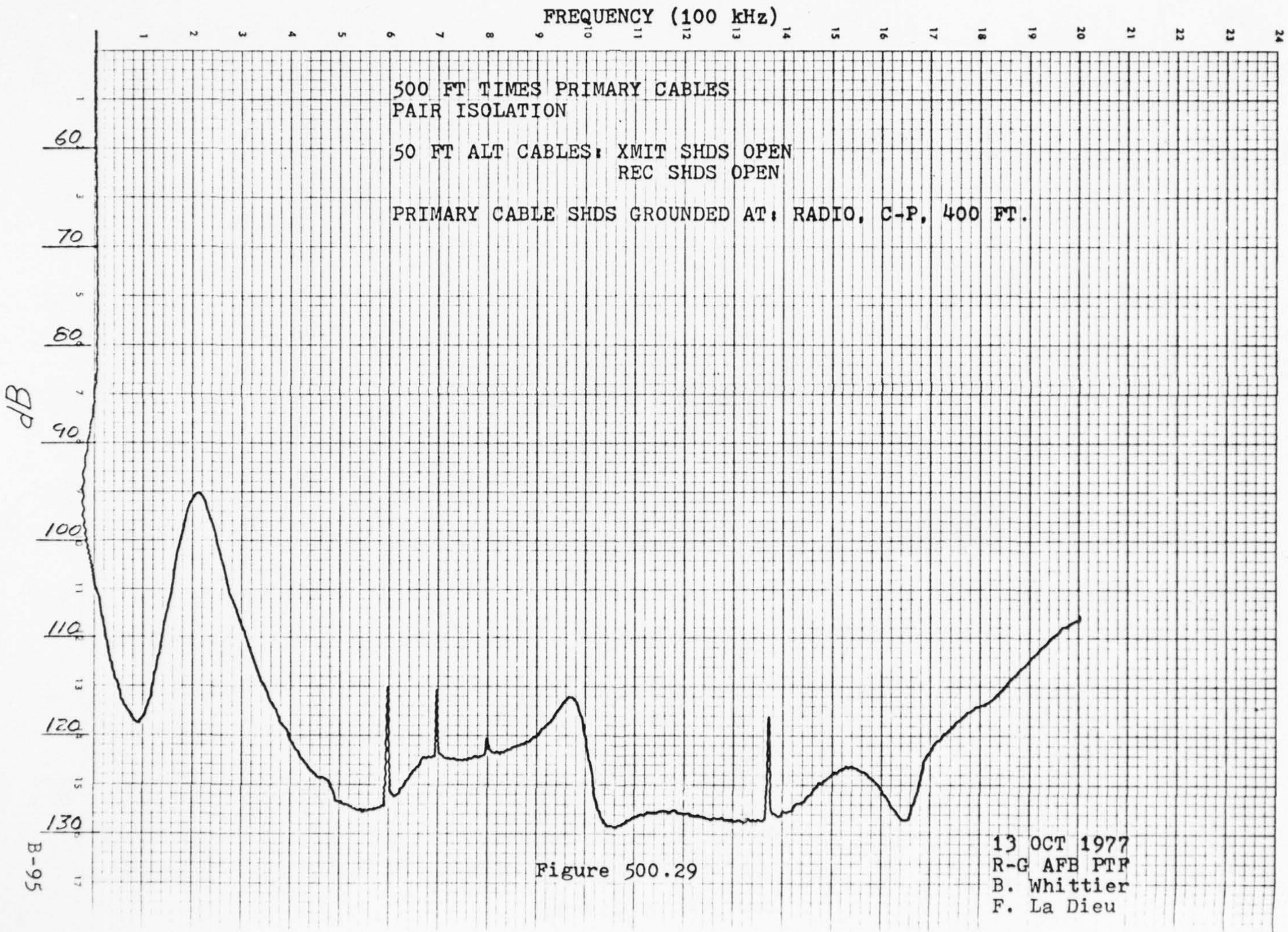


Figure 500.29

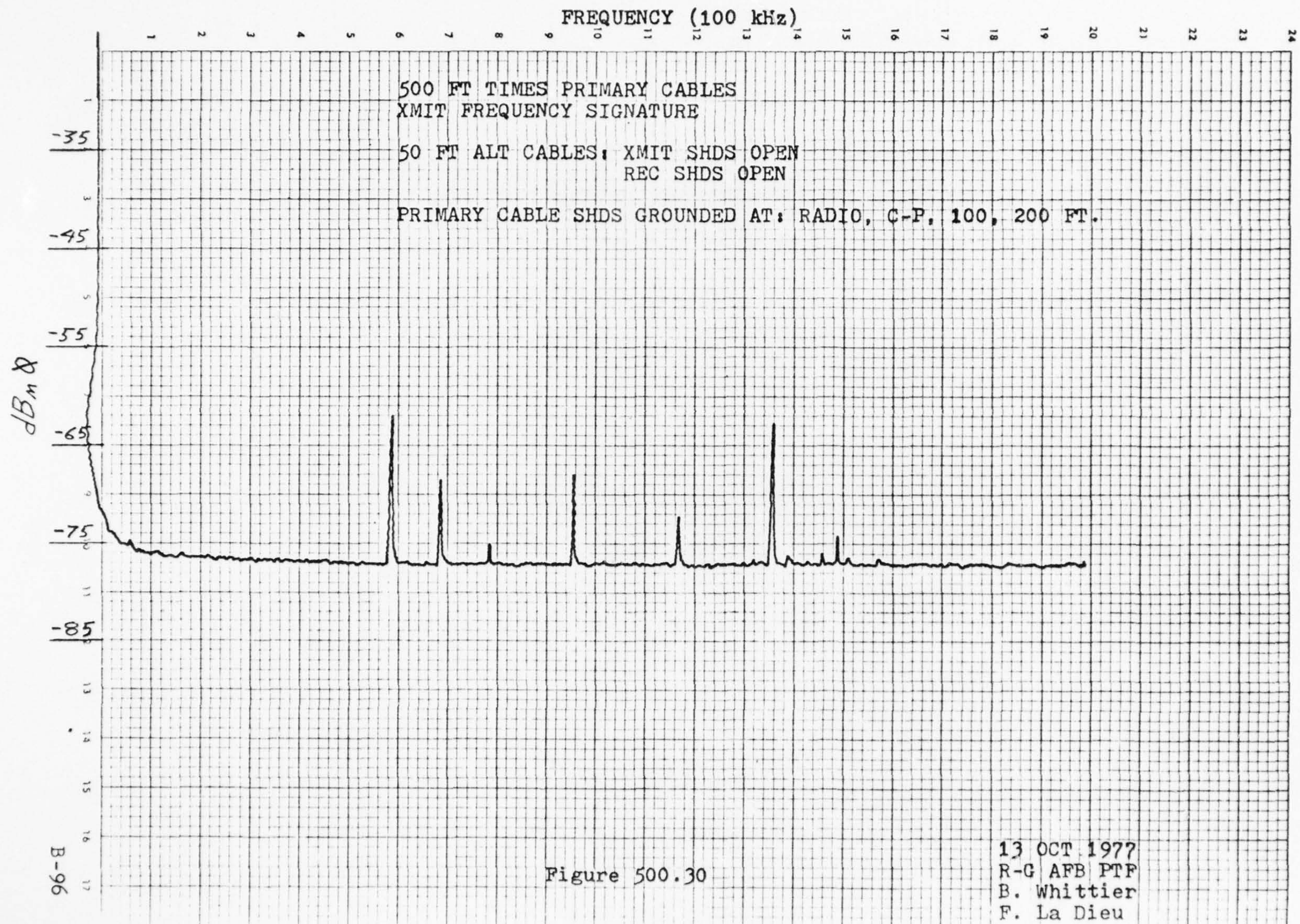


Figure 500.30

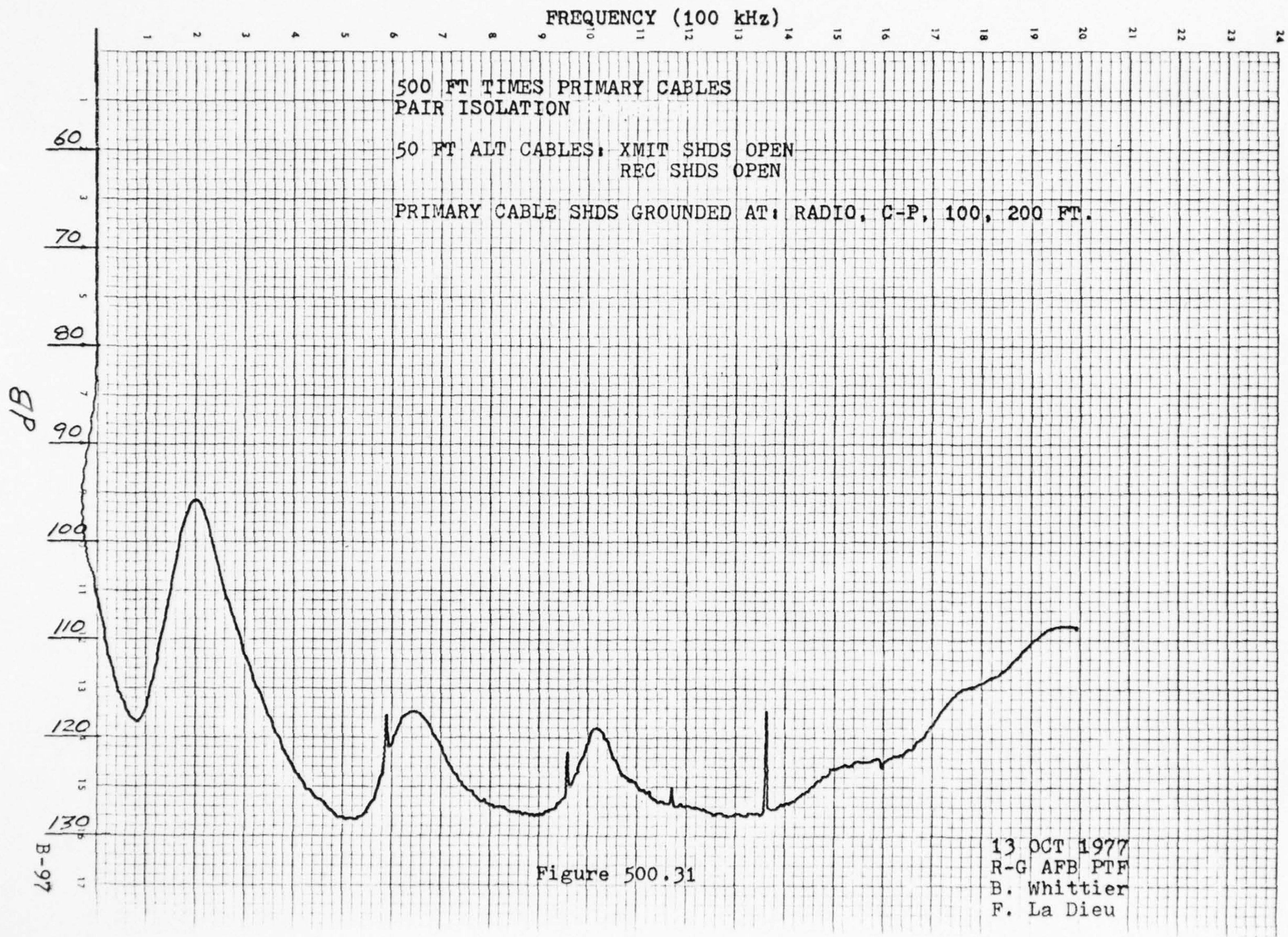


Figure 500.31

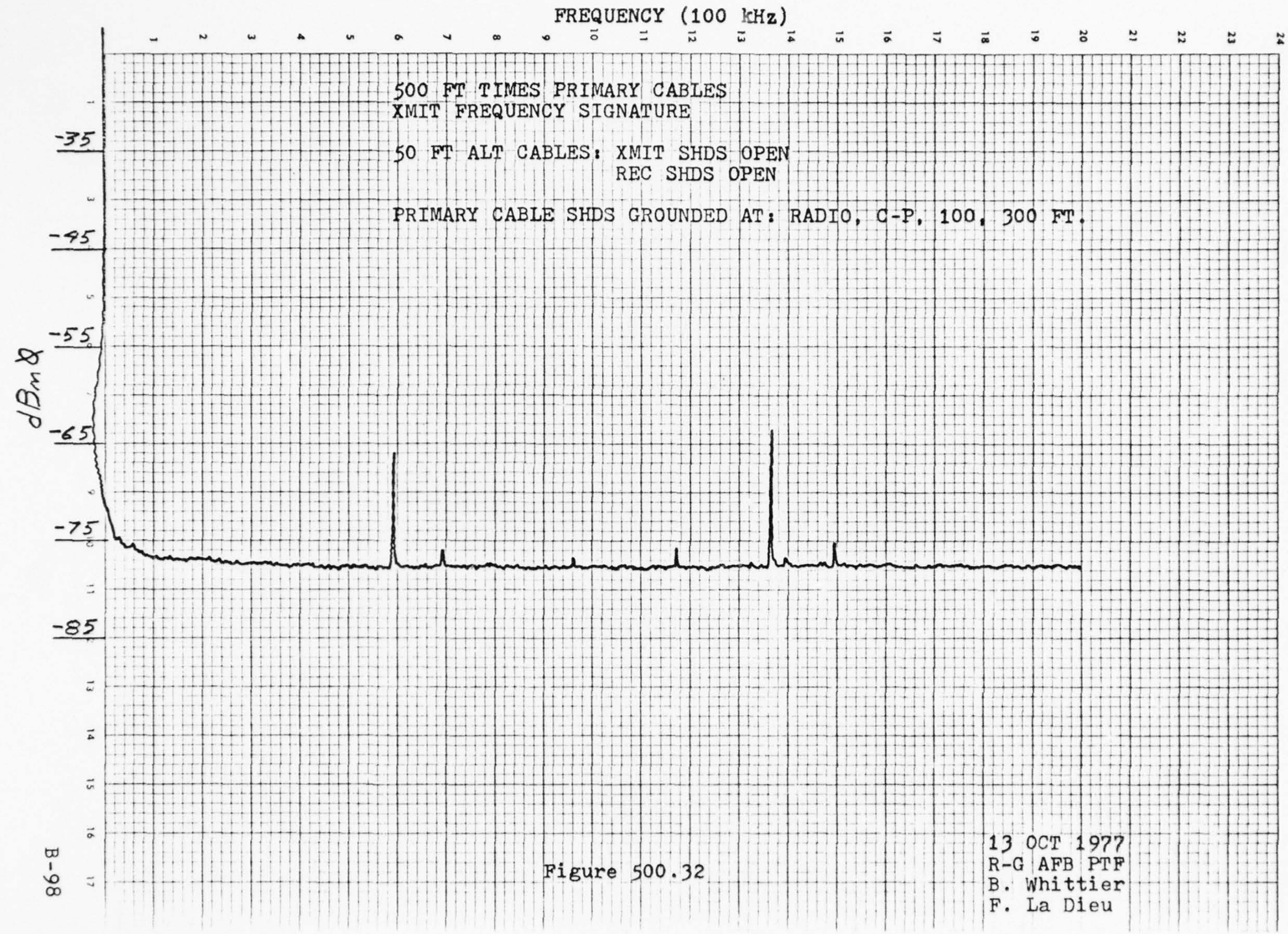


Figure 500.32

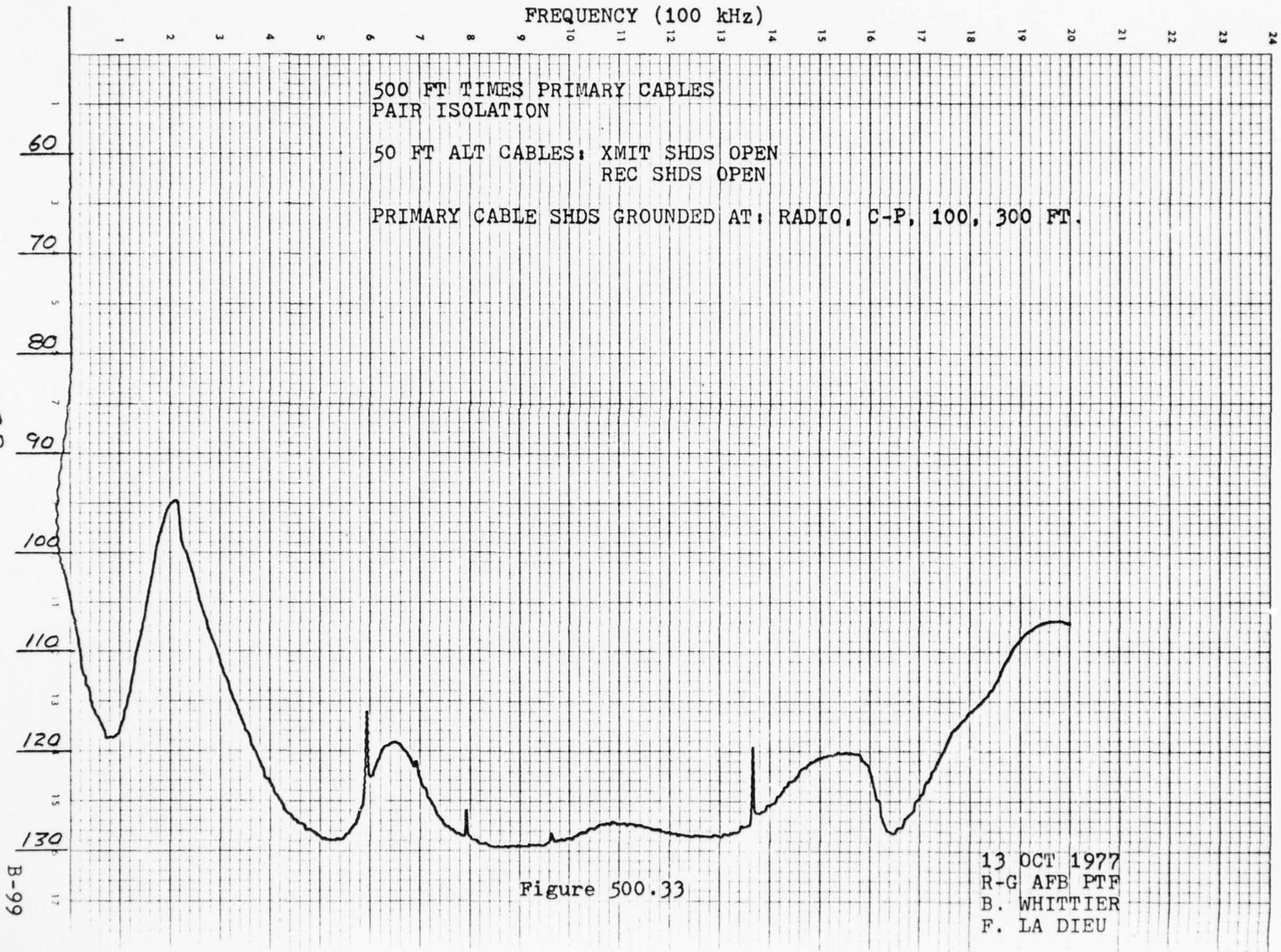


Figure 500.33

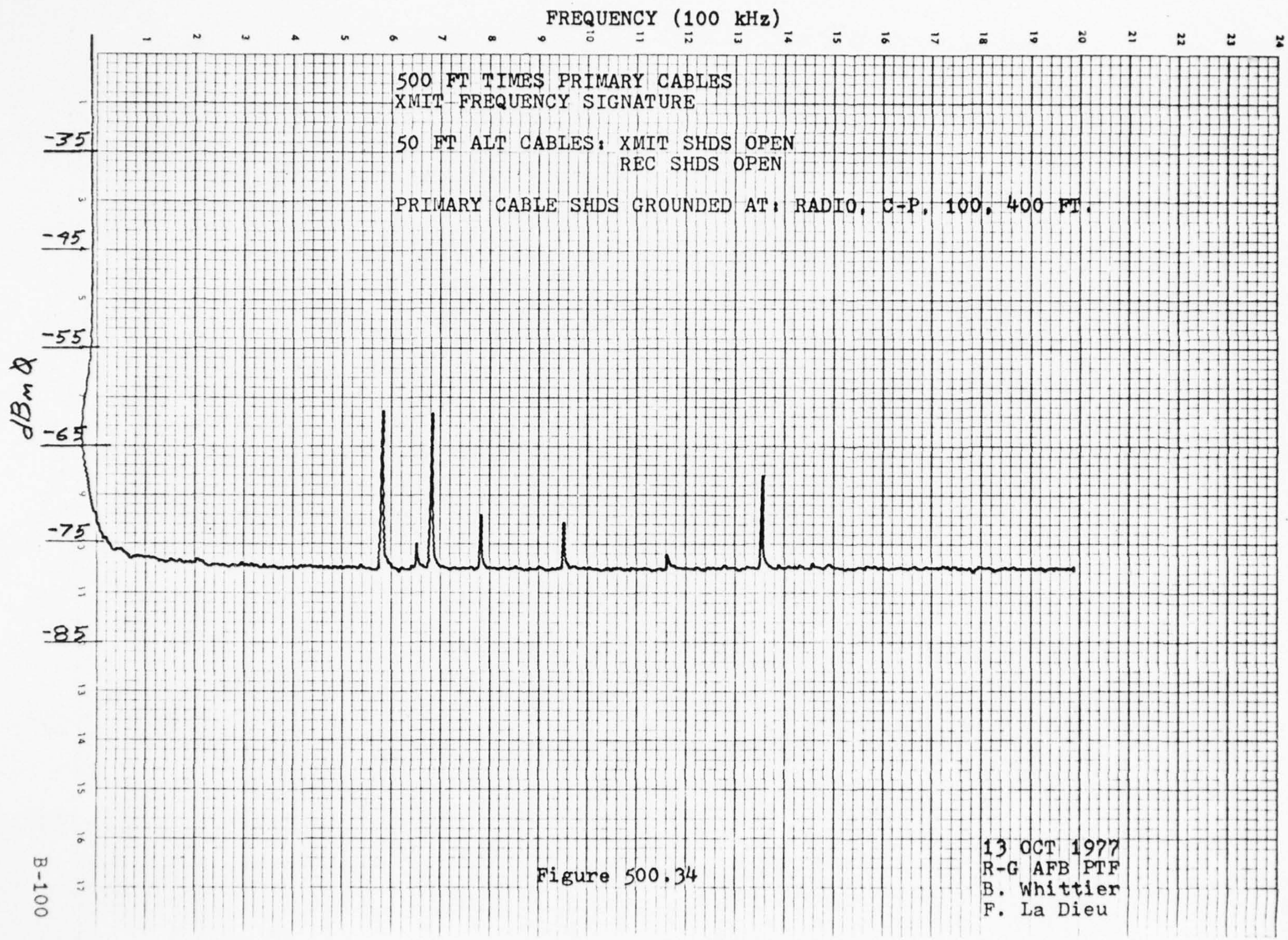


Figure 500.34

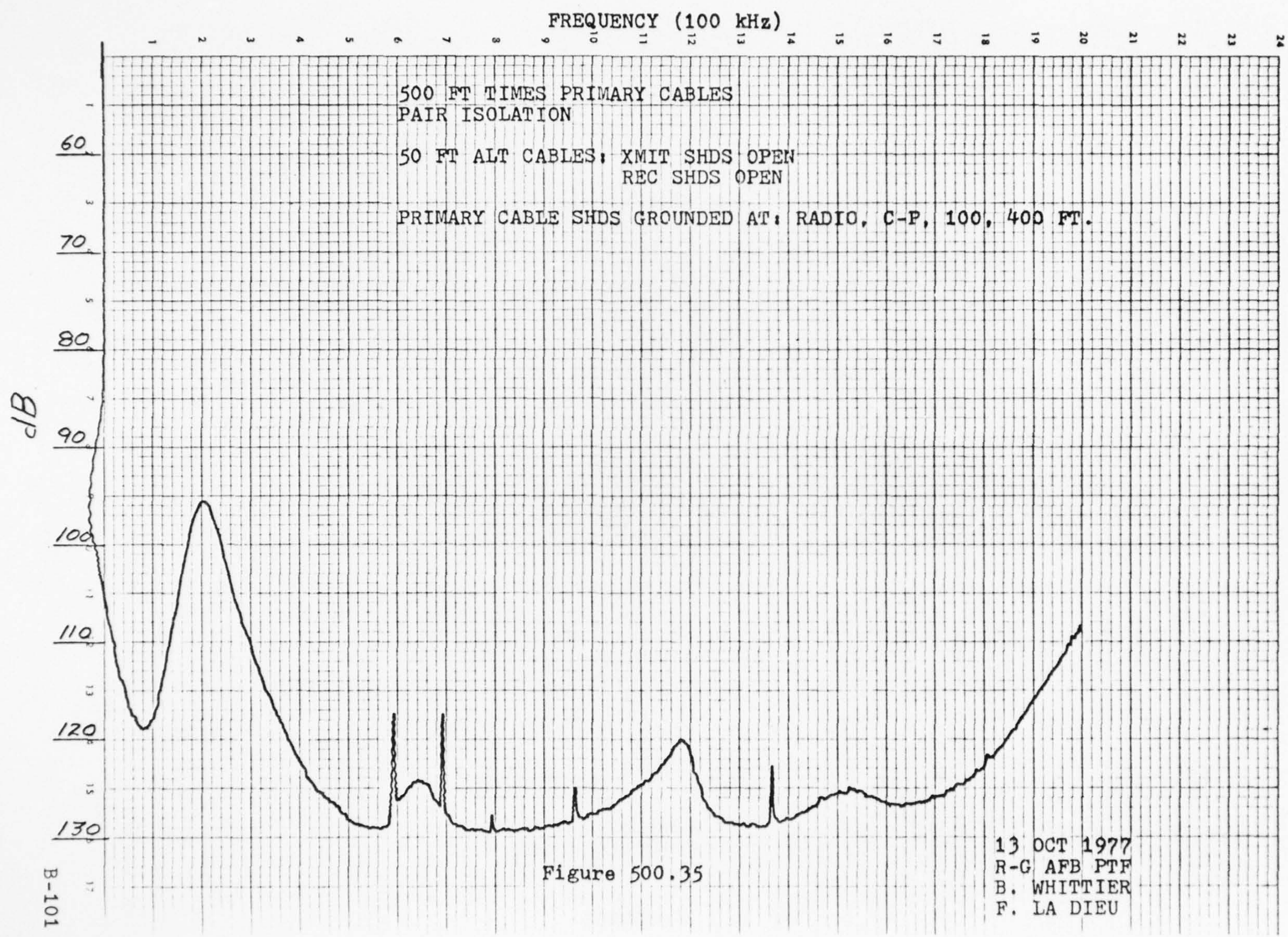


Figure 500.35

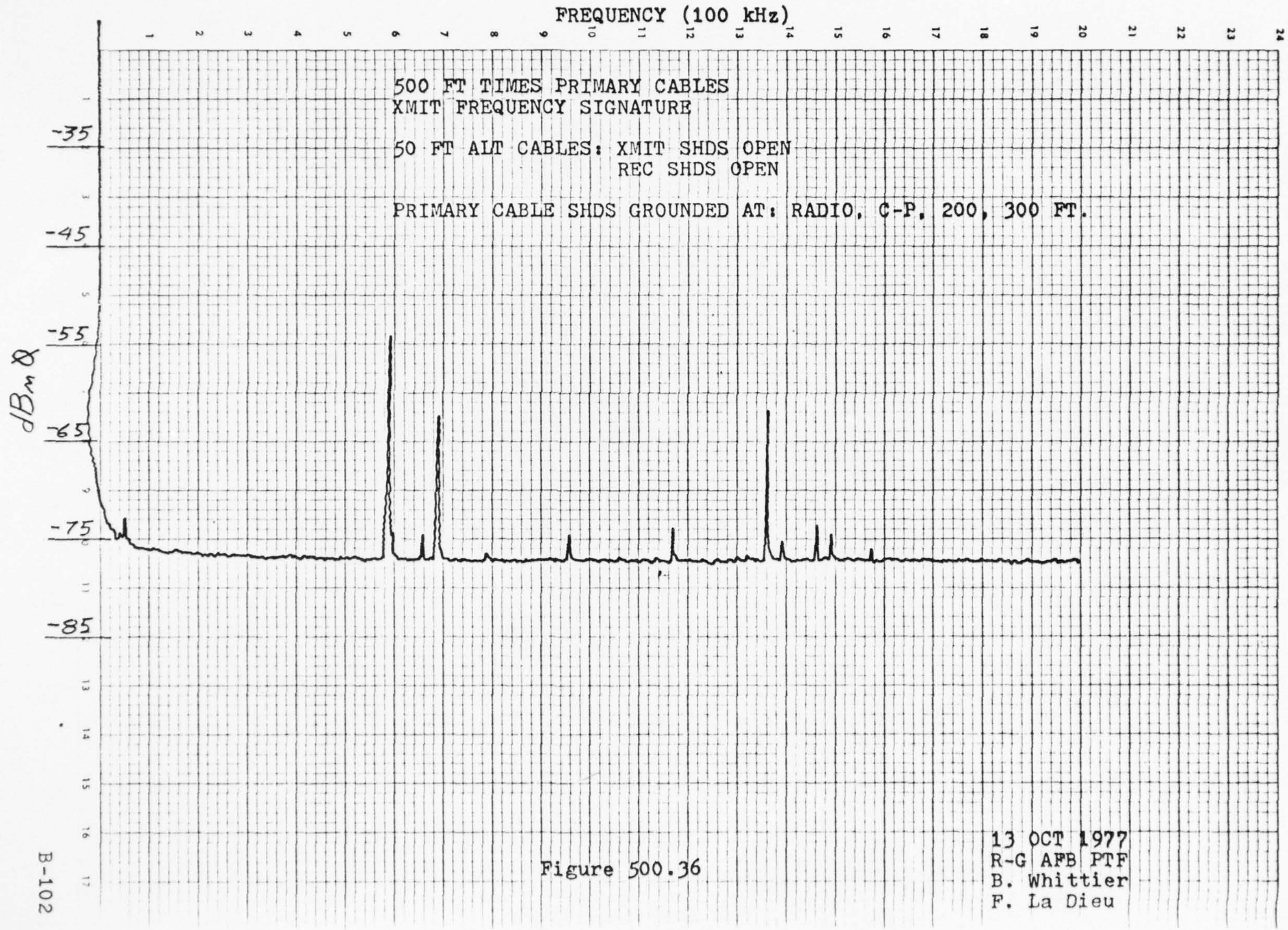


Figure 500.36

13 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

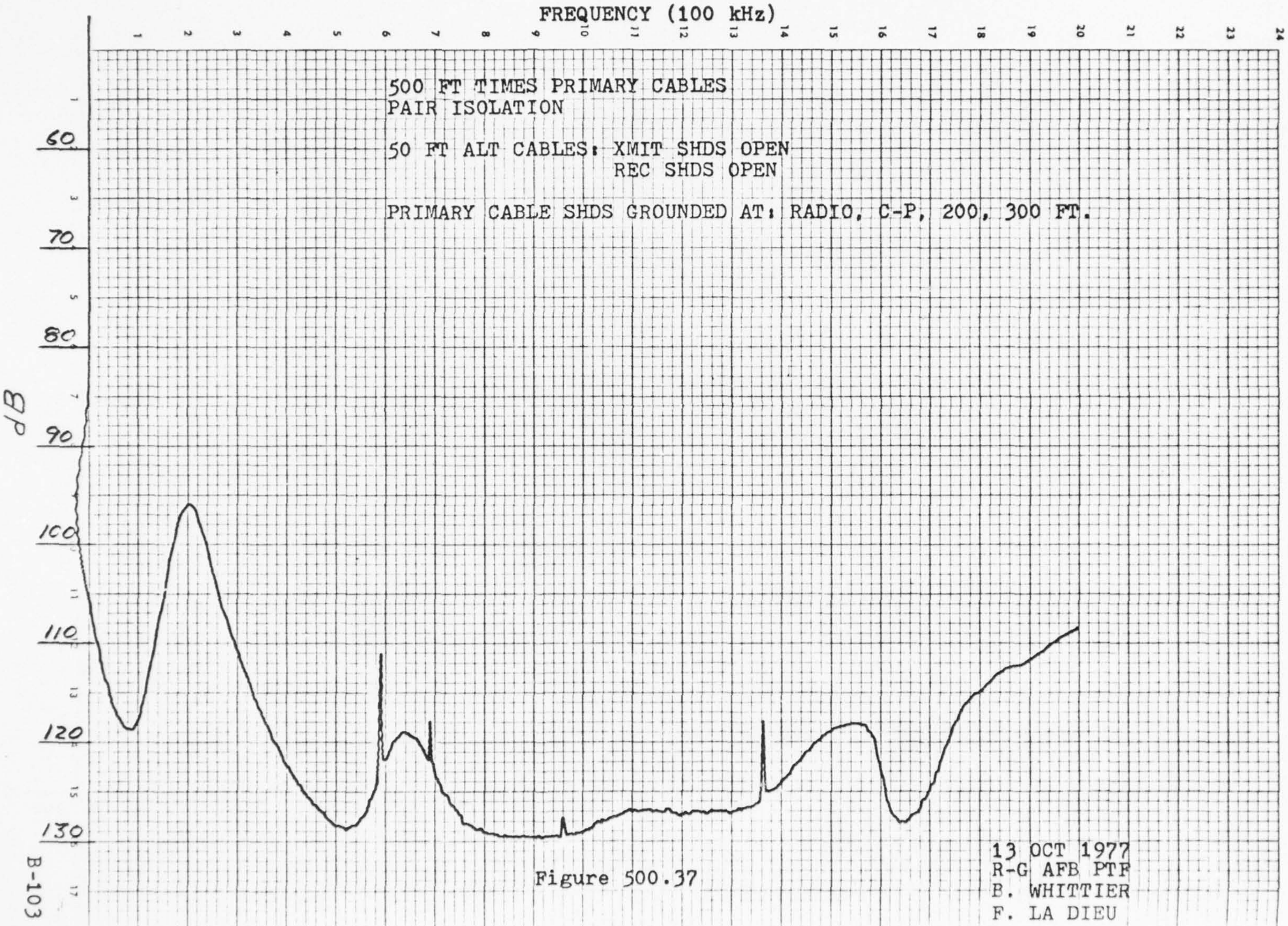


Figure 500.37

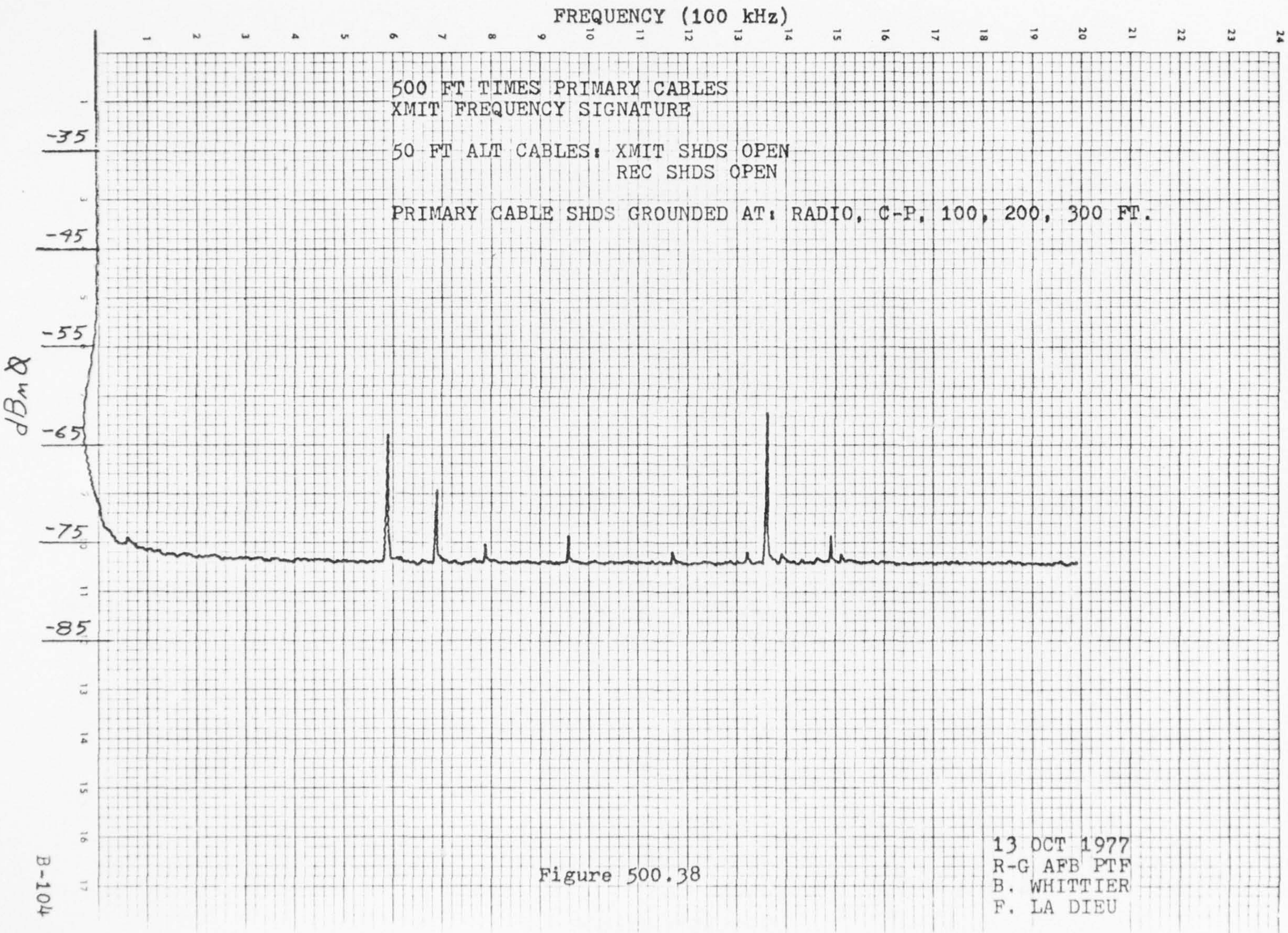


Figure 500.38

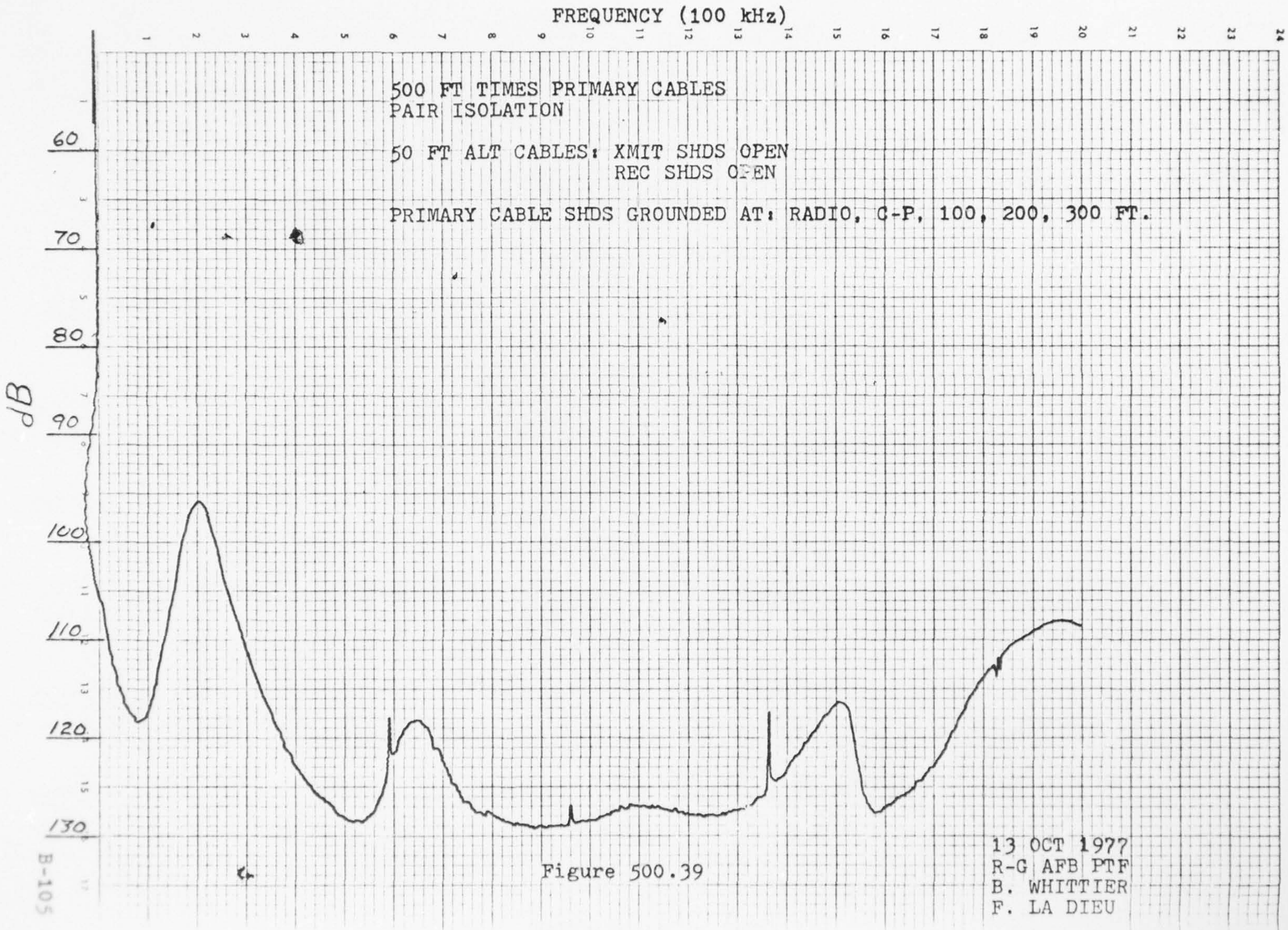
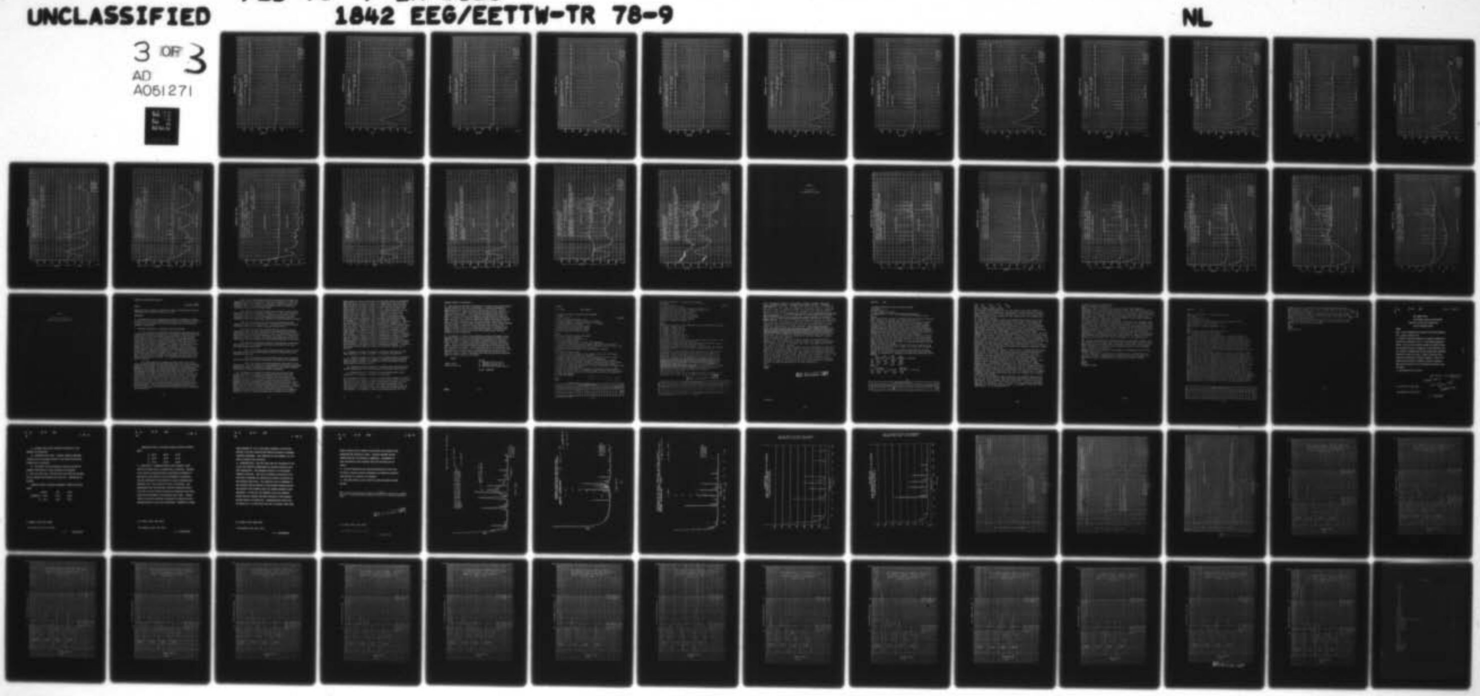


Figure 500.39

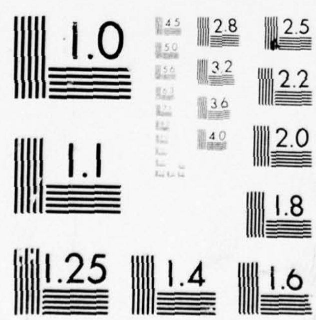
AD-A051 271 ELECTRONICS ENGINEERING GROUP (1842ND) SCOTT AFB IL F/G 17/2
FREQUENCY DIVISION MULTIPLEX BASEBAND CABLE PLANT PERFORMANCE I--ETC(U)
FEB 78 F LA DIEU
UNCLASSIFIED 1842 EEG/EETTW-TR 78-9 NL

3 OF 3
AD
A051271



END
DATE
FILMED
4-78
DDC

05127



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

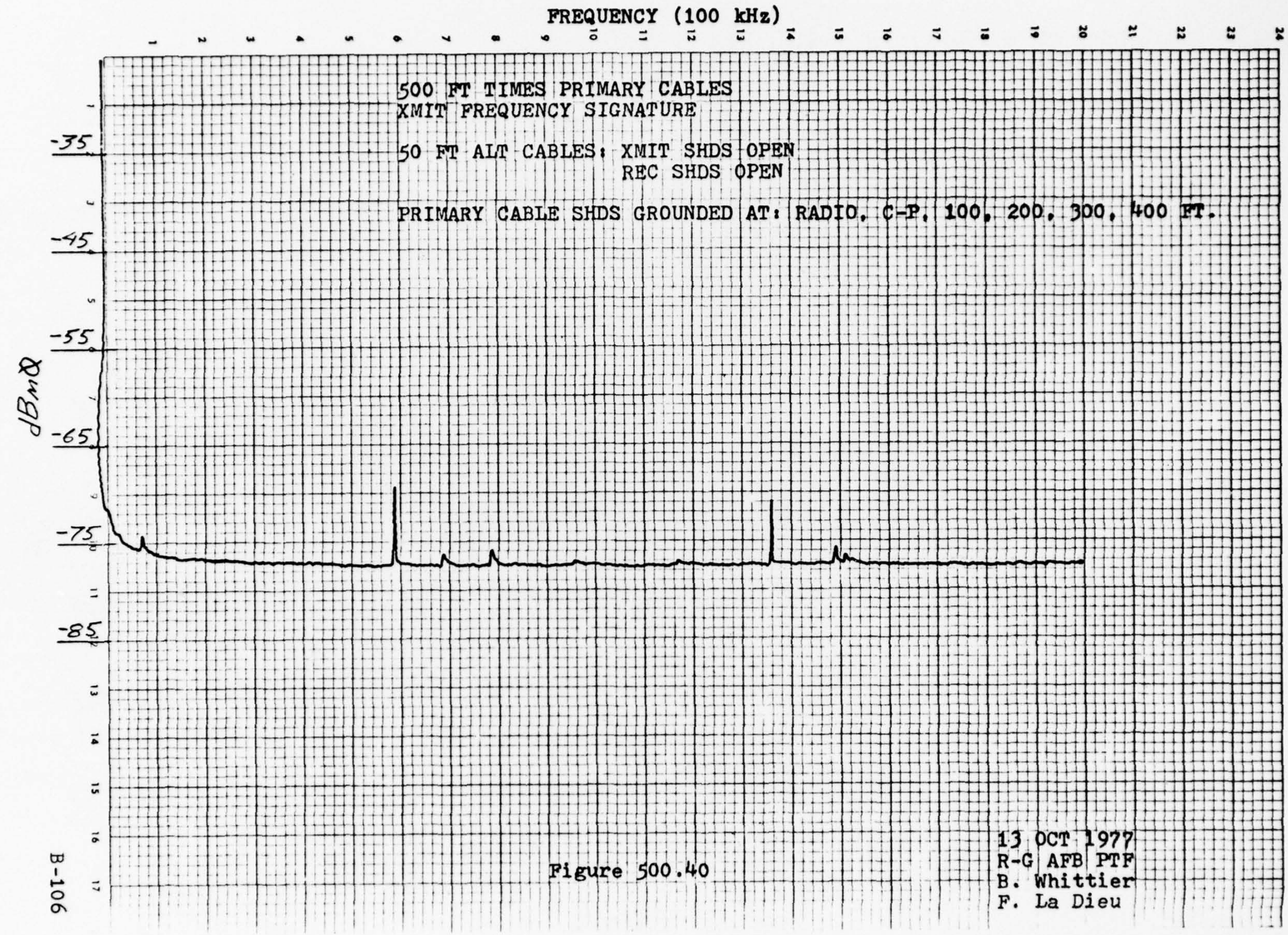


Figure 500.40

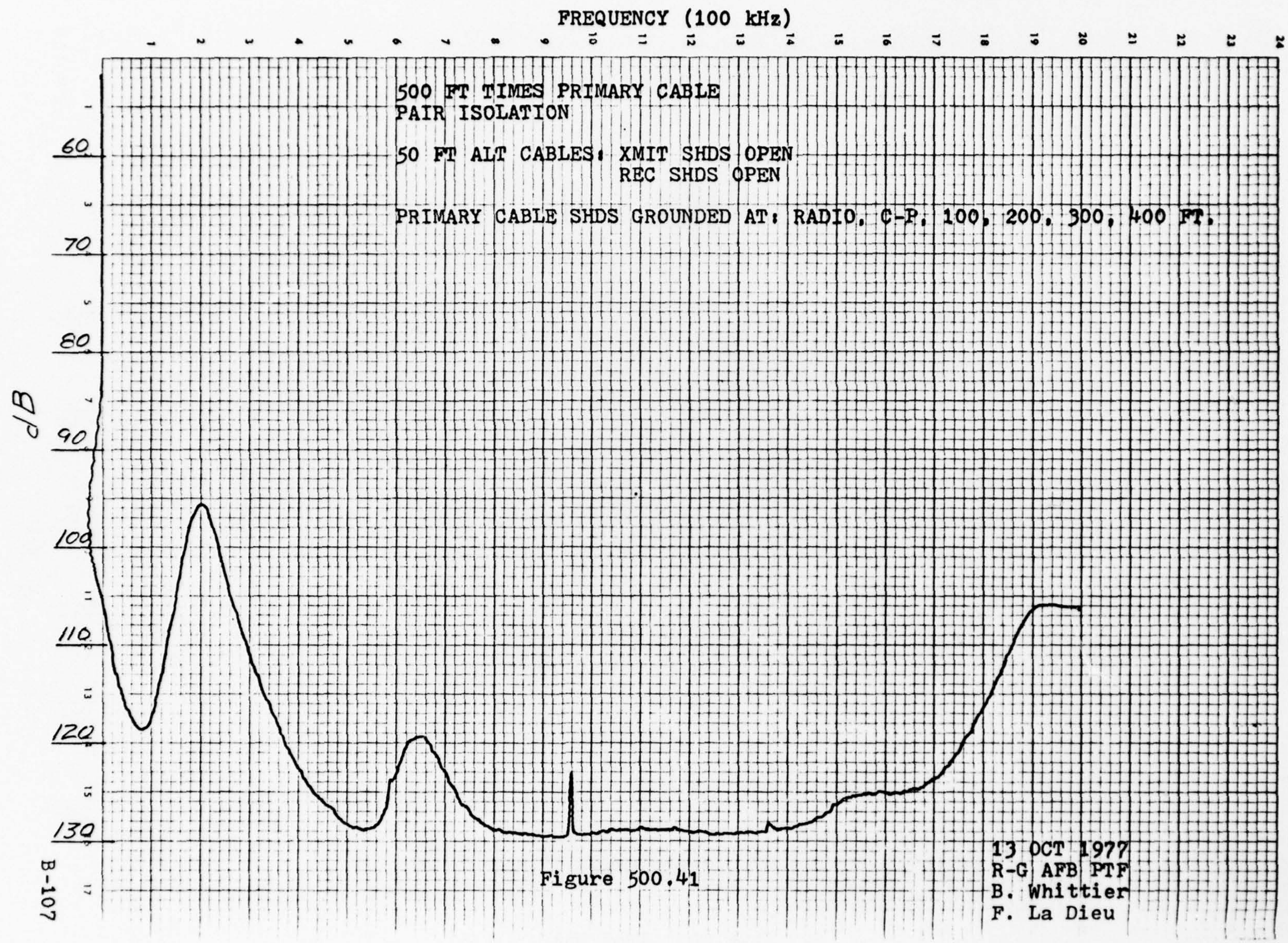


Figure 500.41

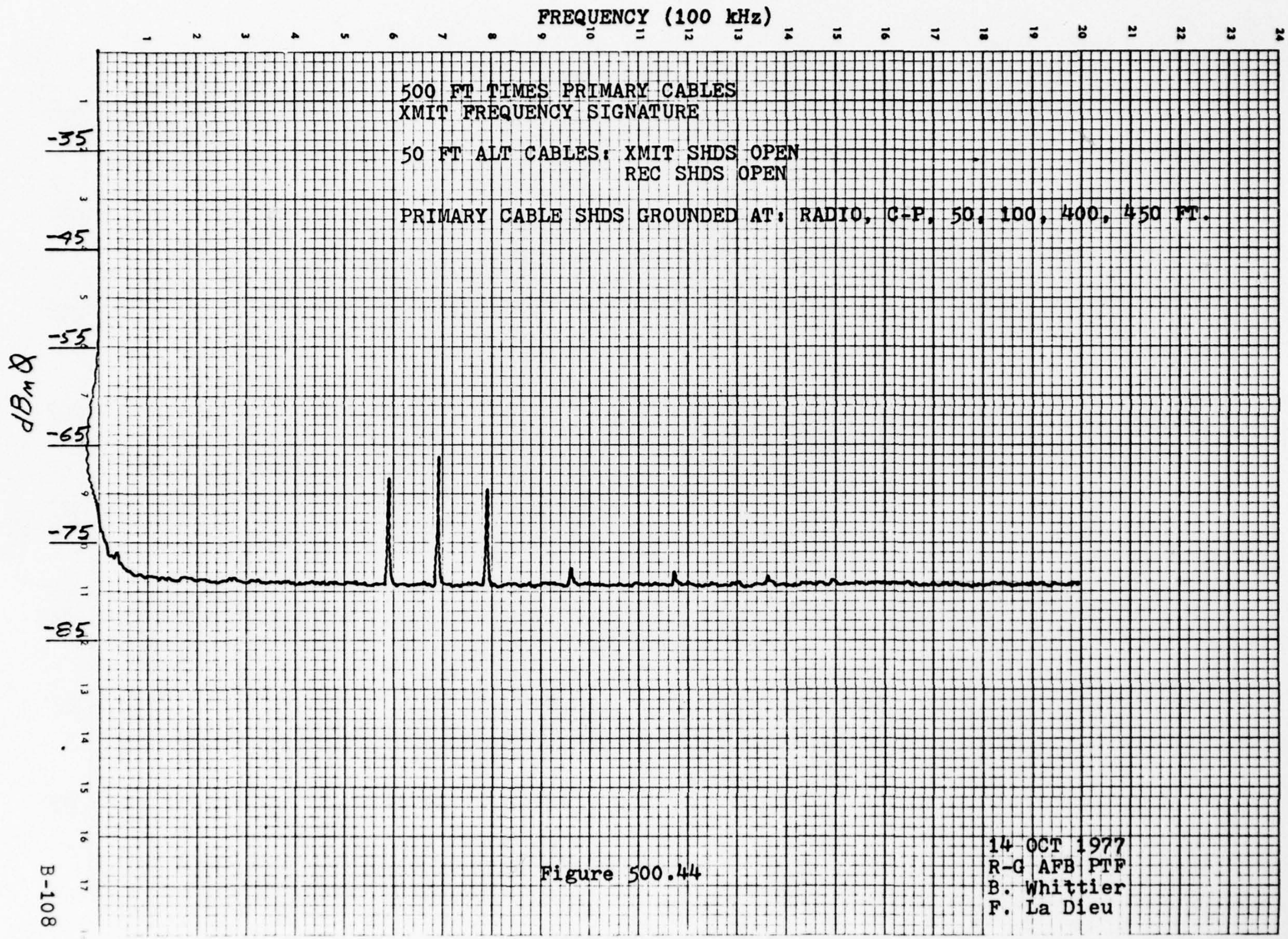
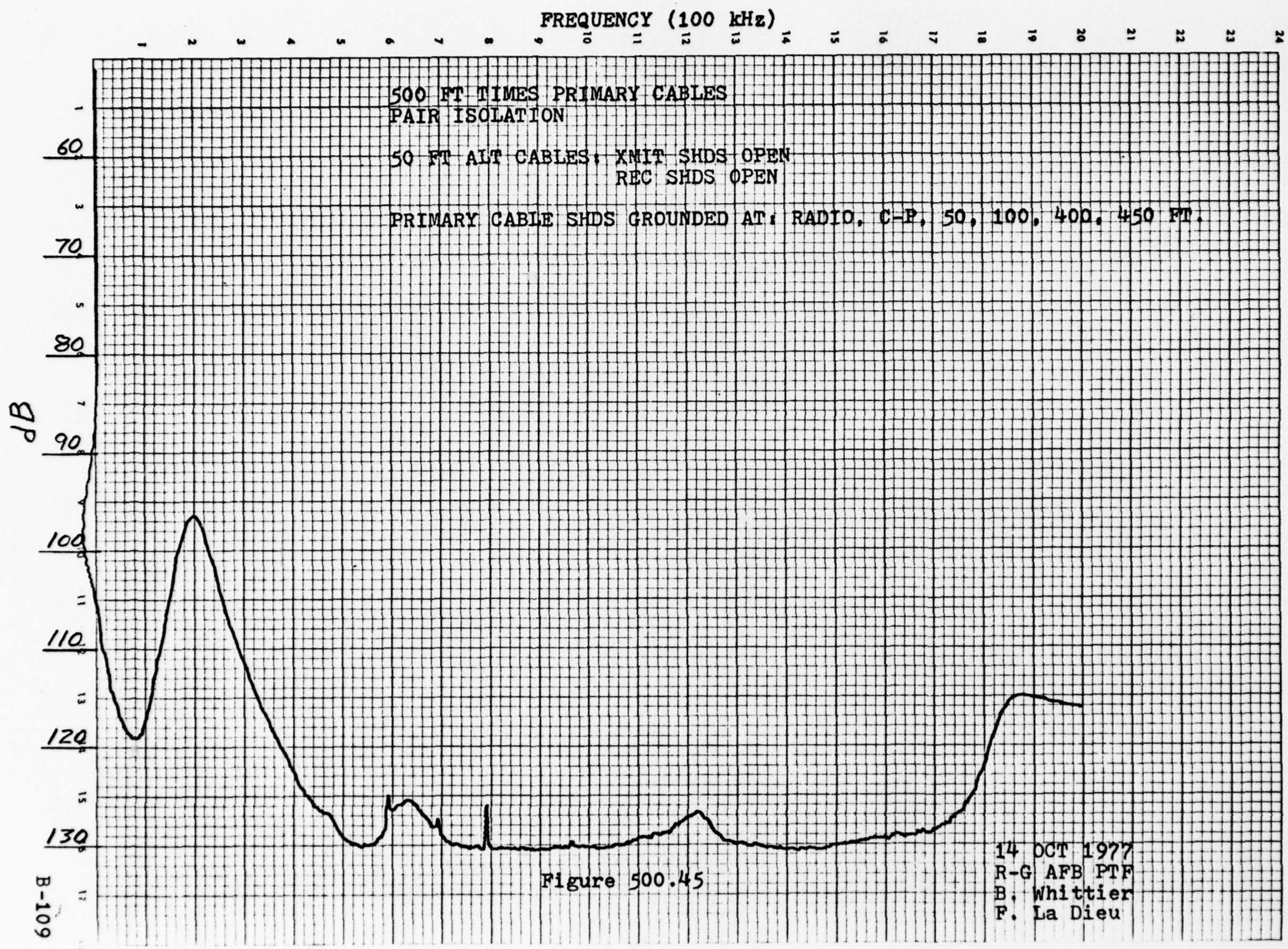


Figure 500.44



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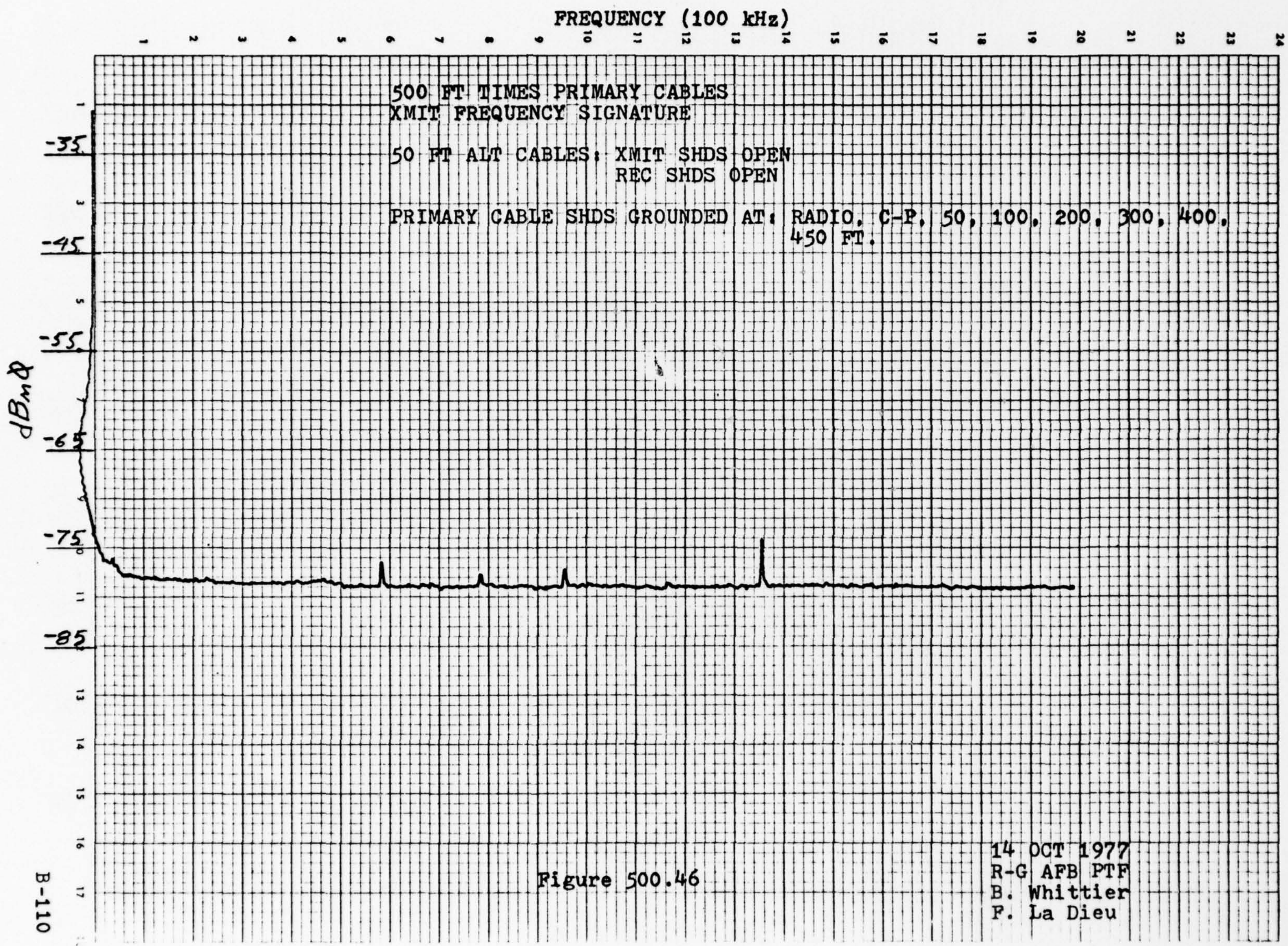


Figure 500.46

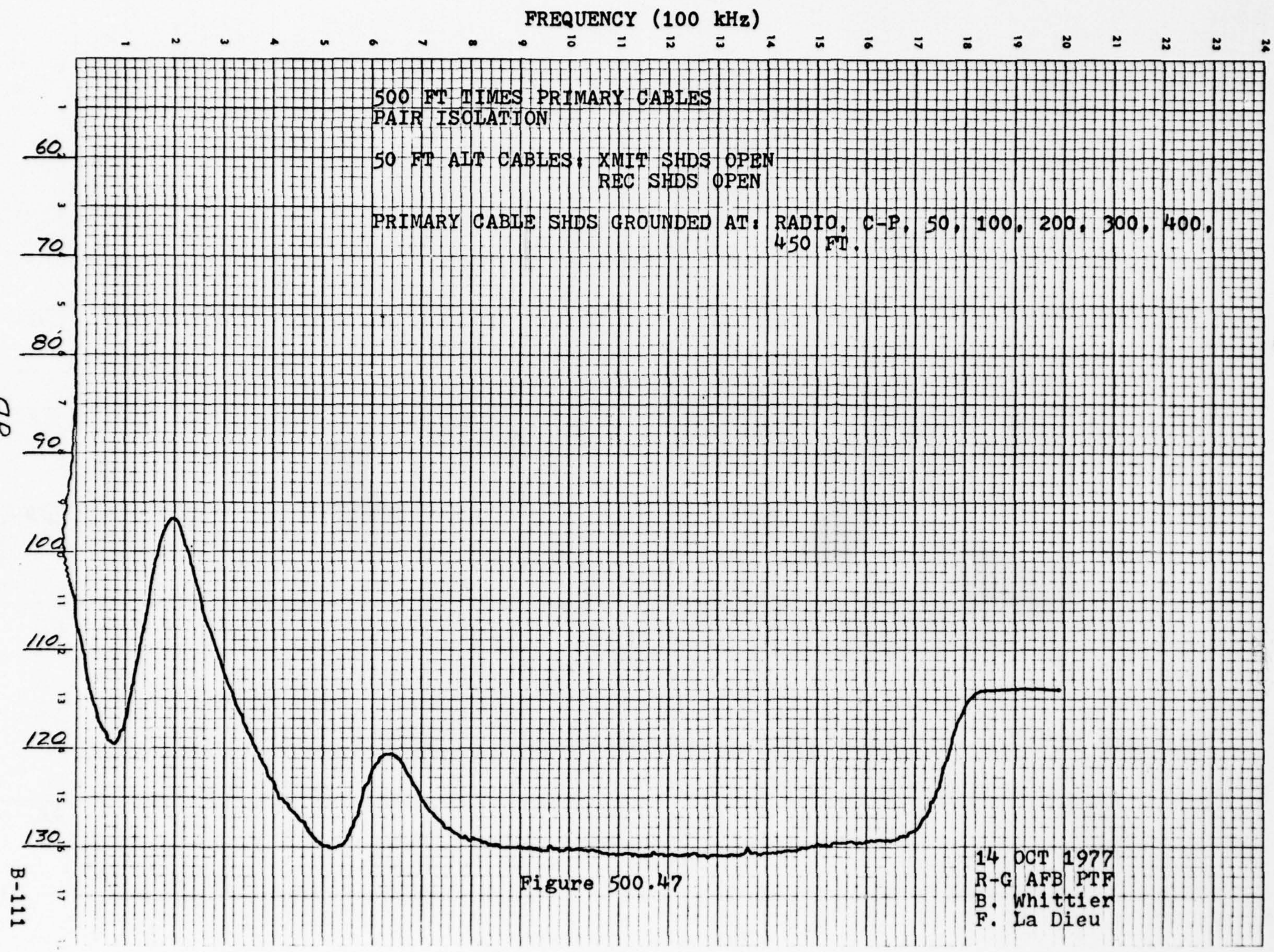


Figure 500.47

14 OCT 1977
R-G AFB PTF
B. Whittier
F. La Dieu

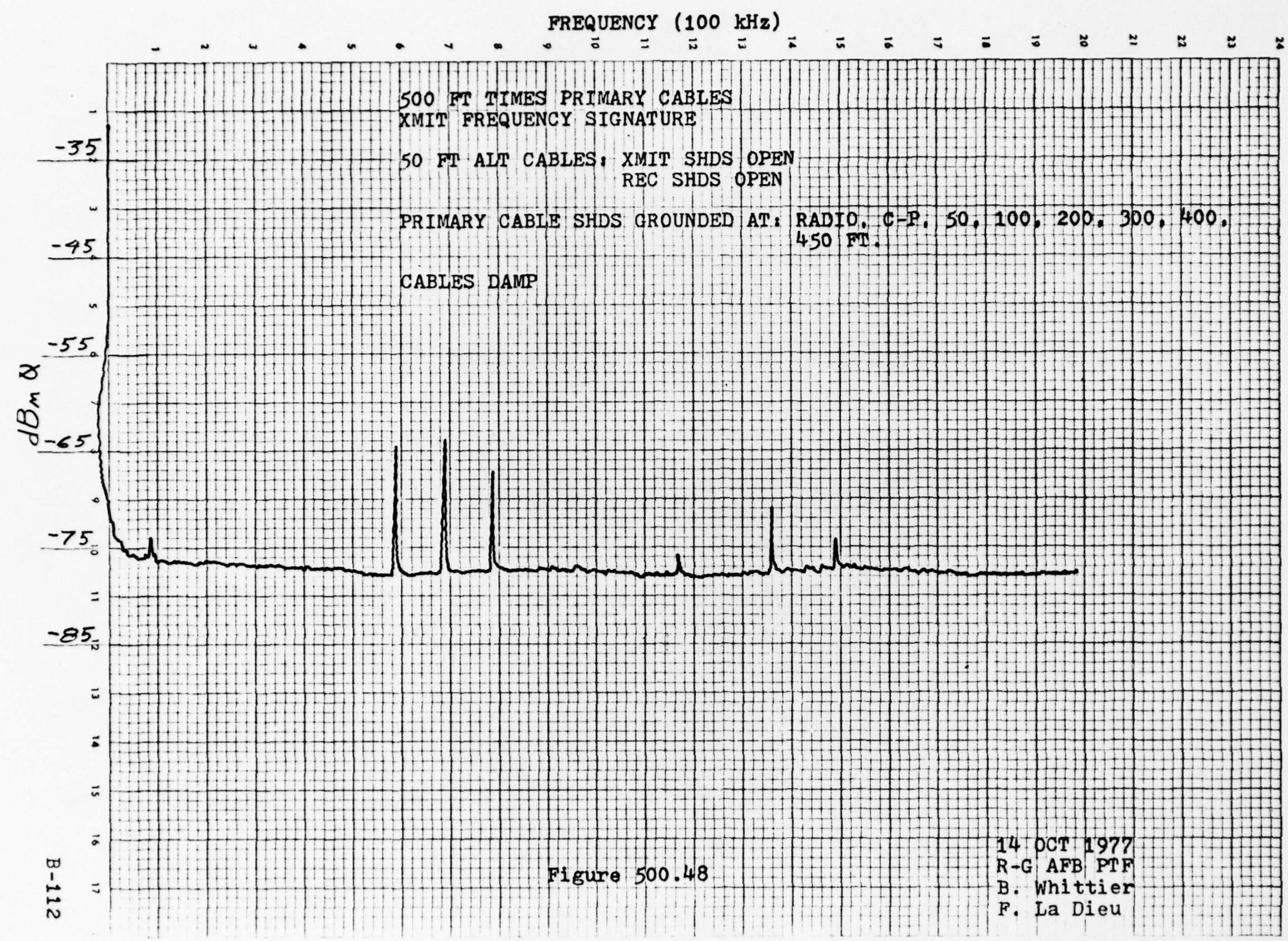


Figure 500.48

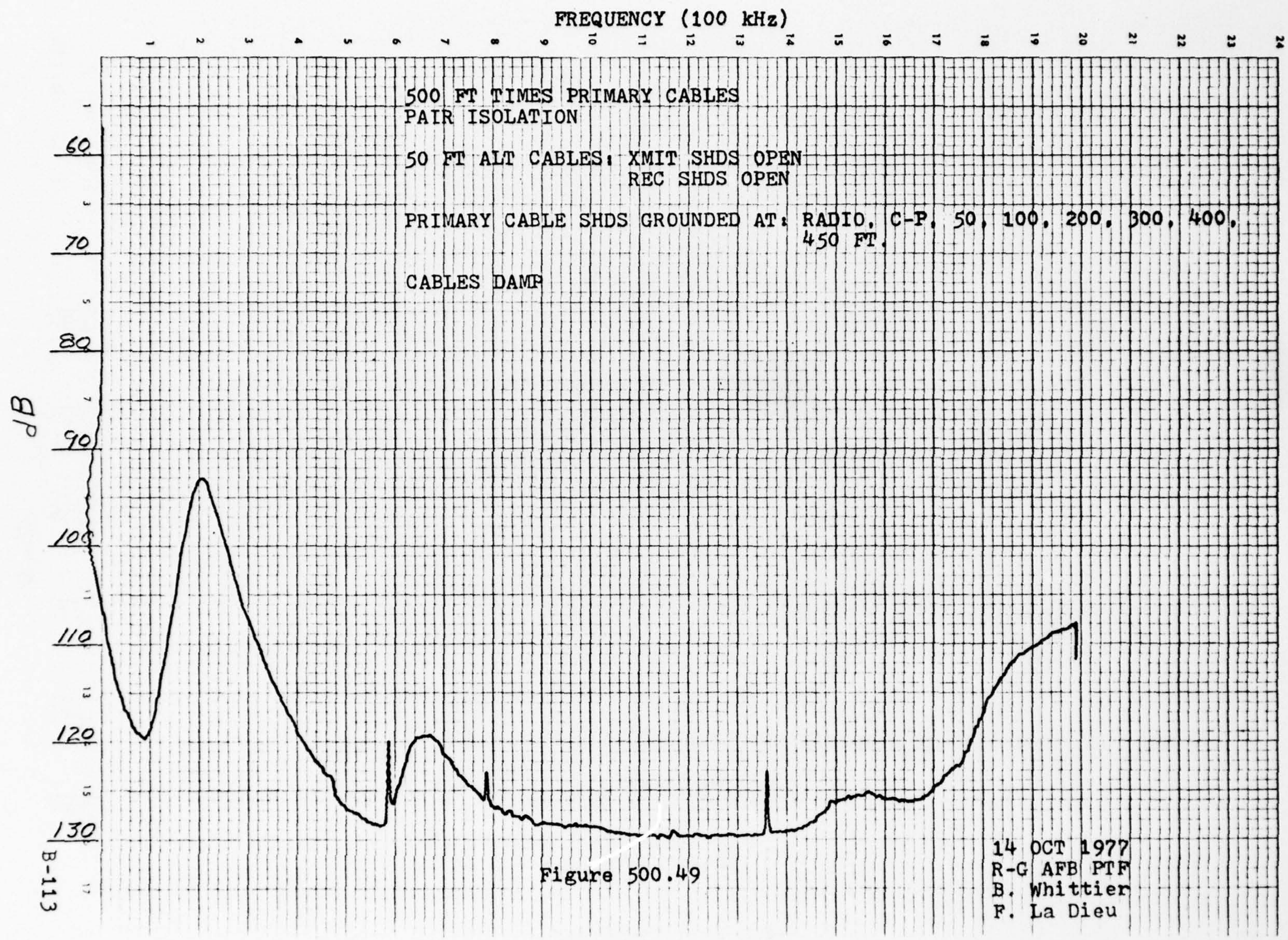


Figure 500.49

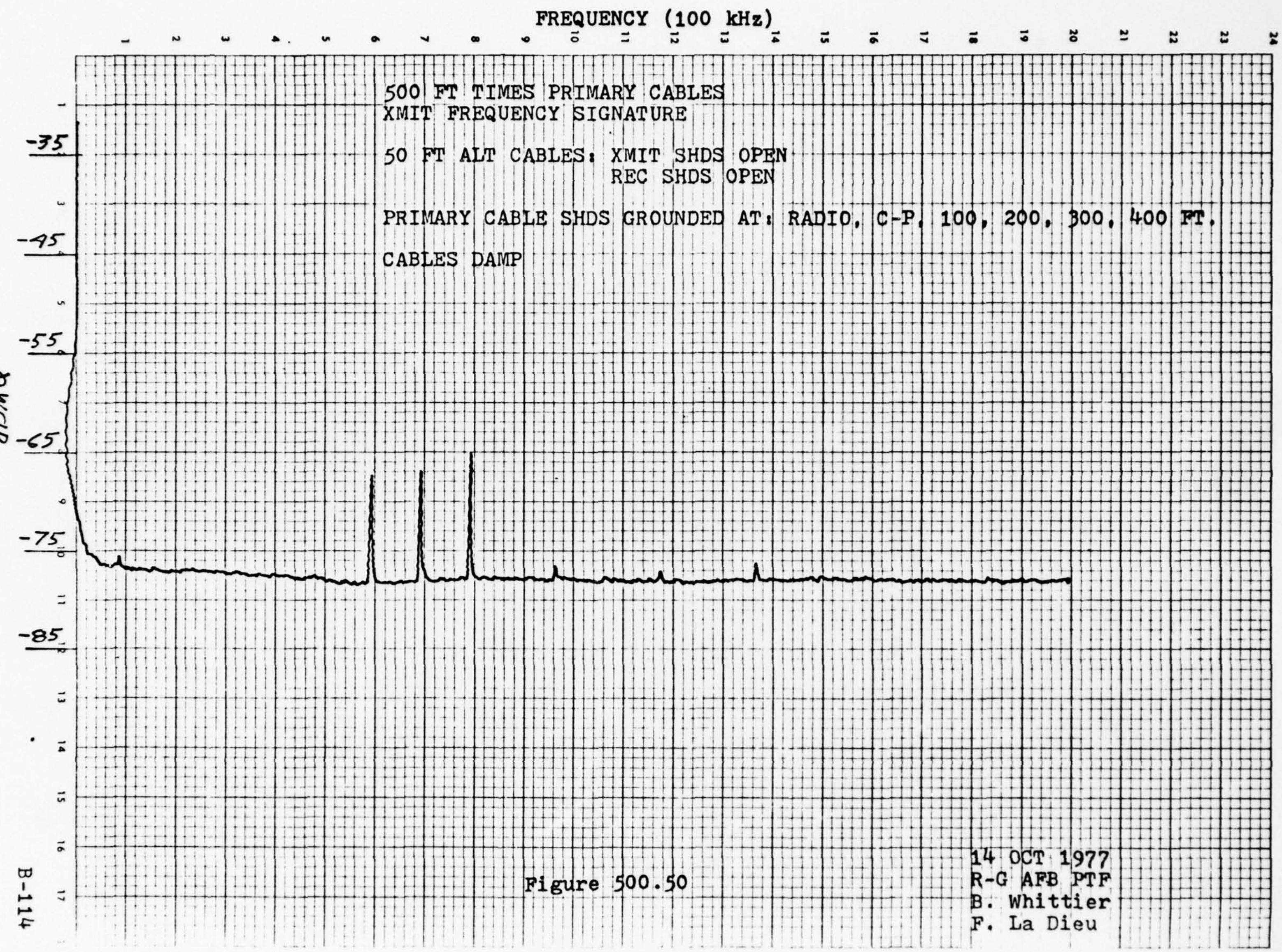
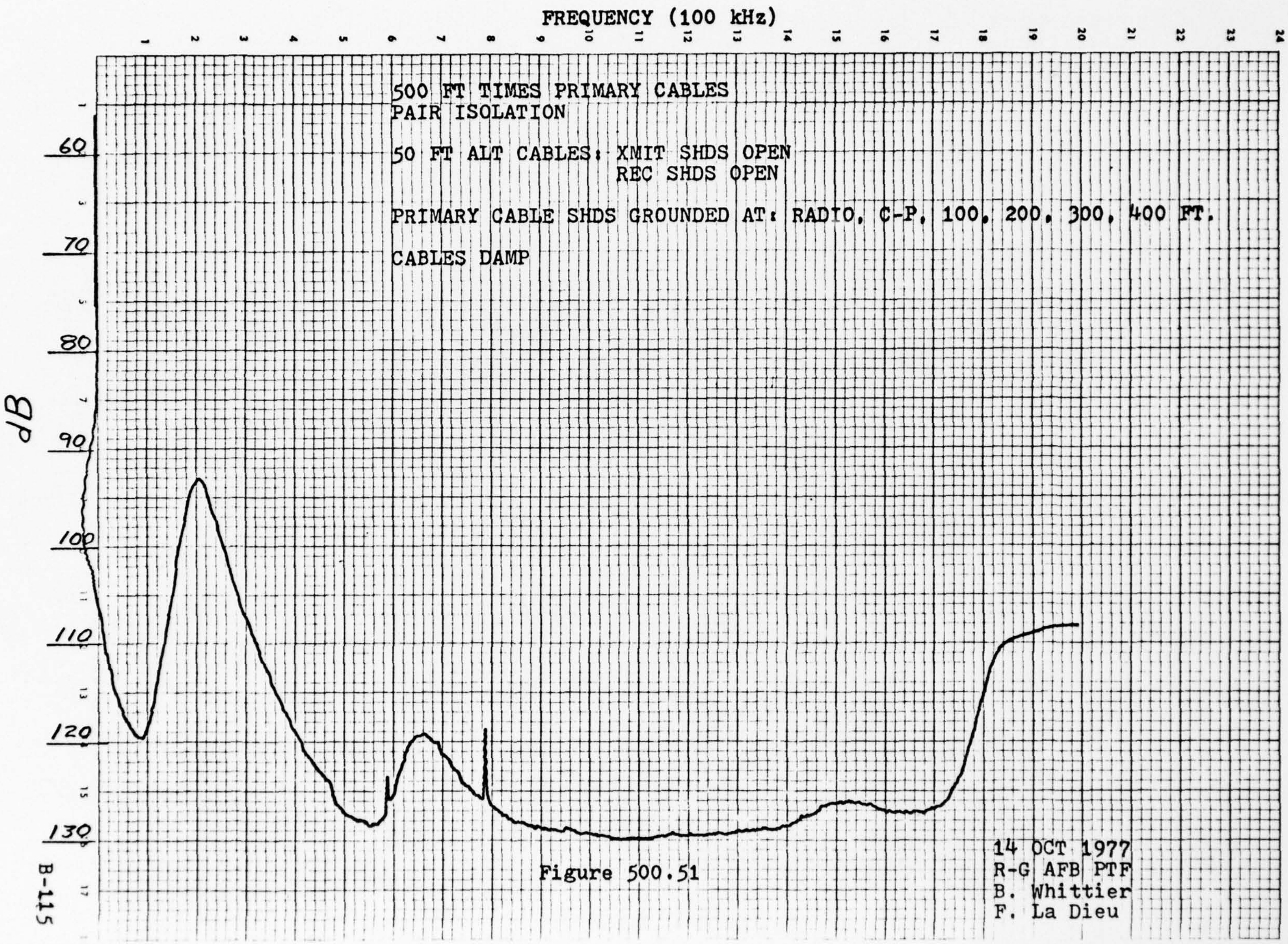


Figure 500.50



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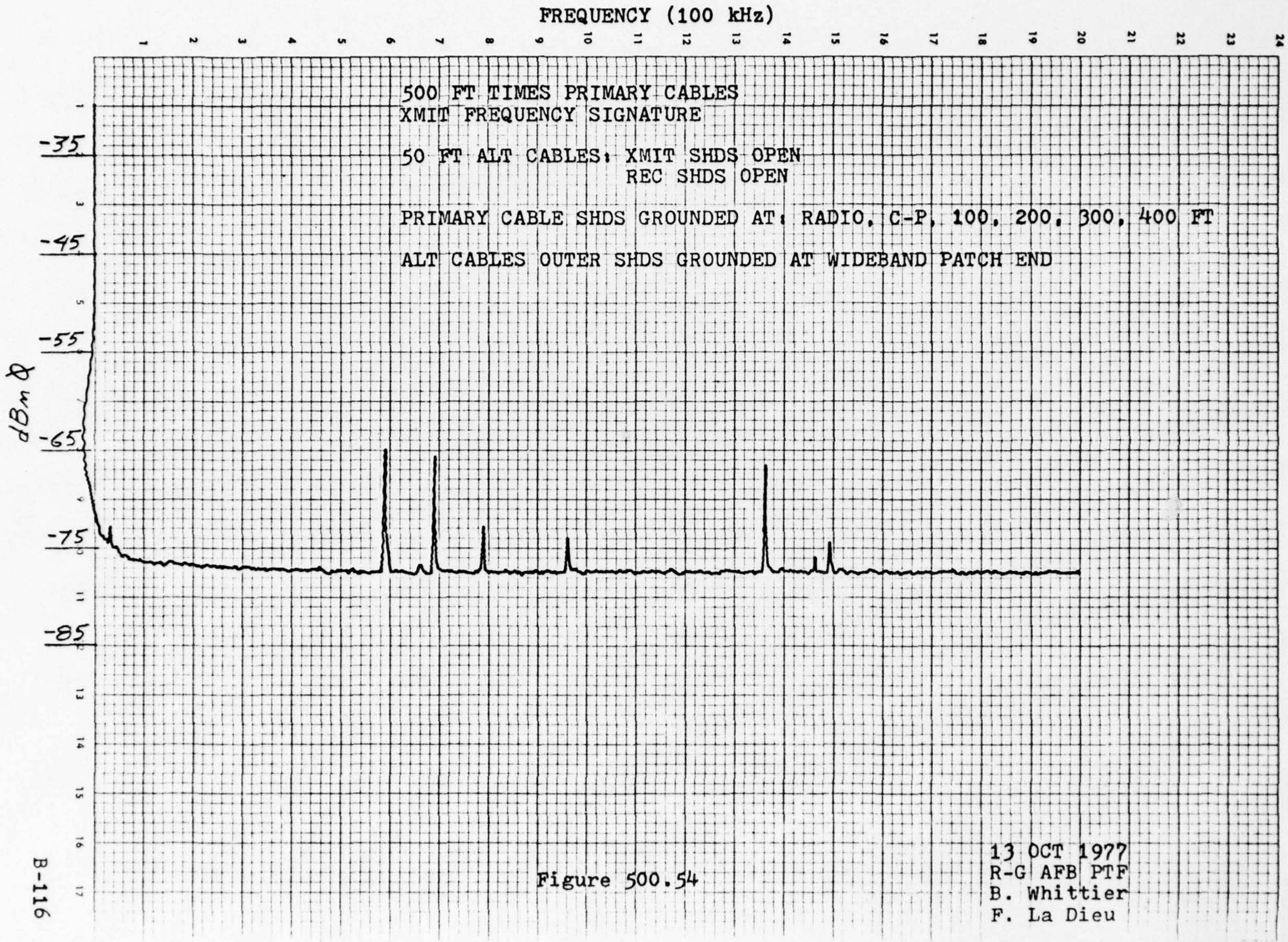

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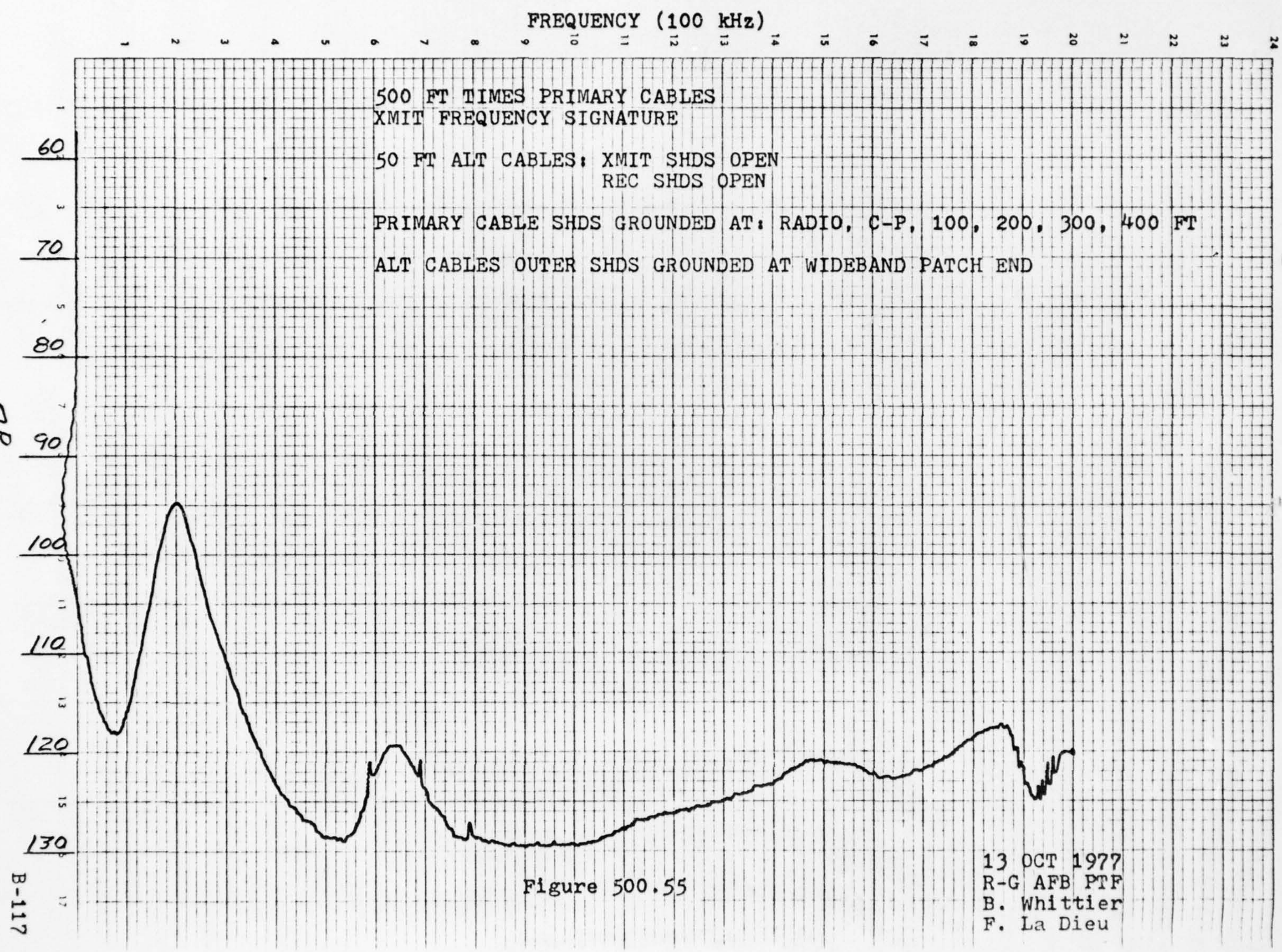


Figure 500.55

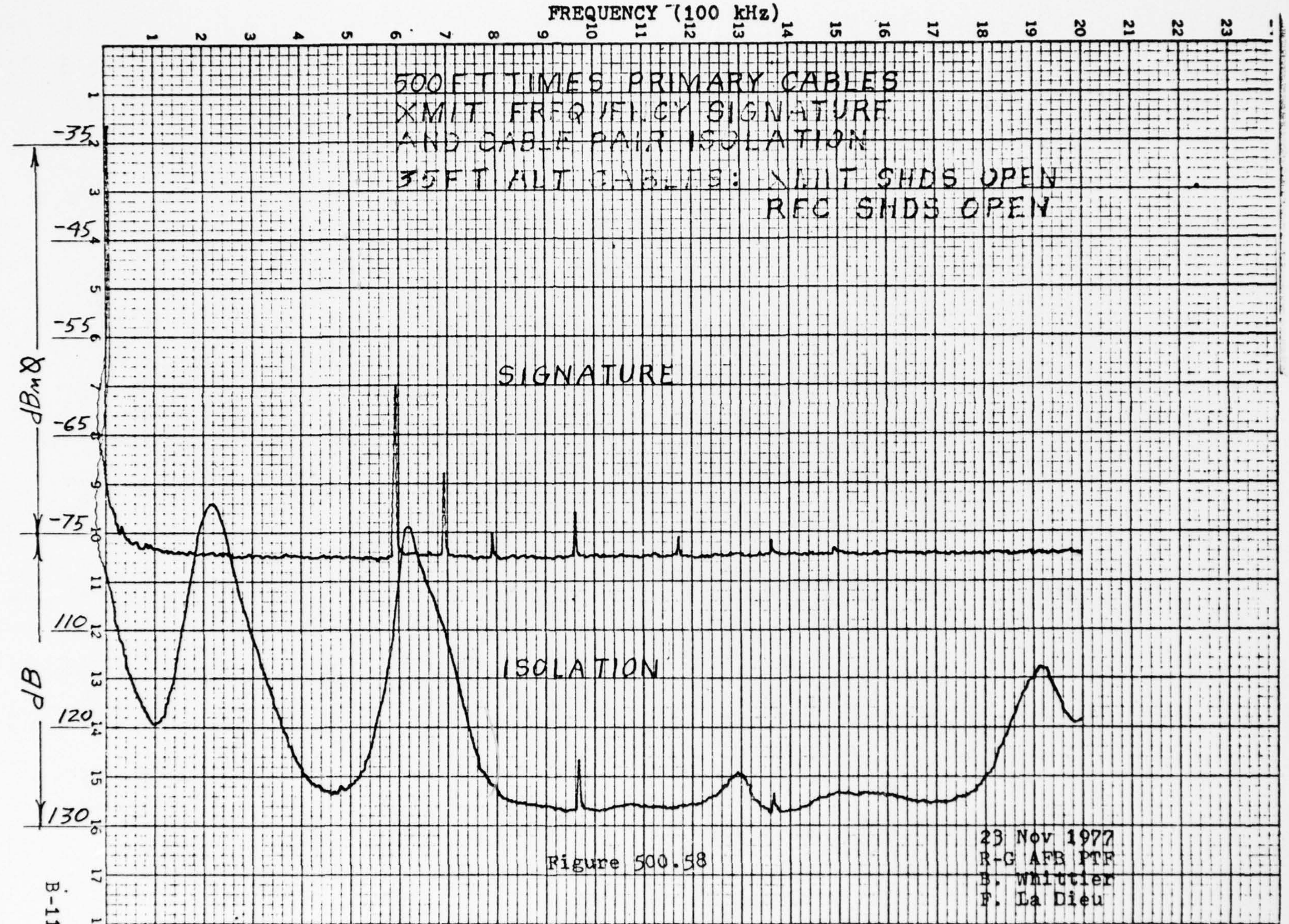


Figure 500.58

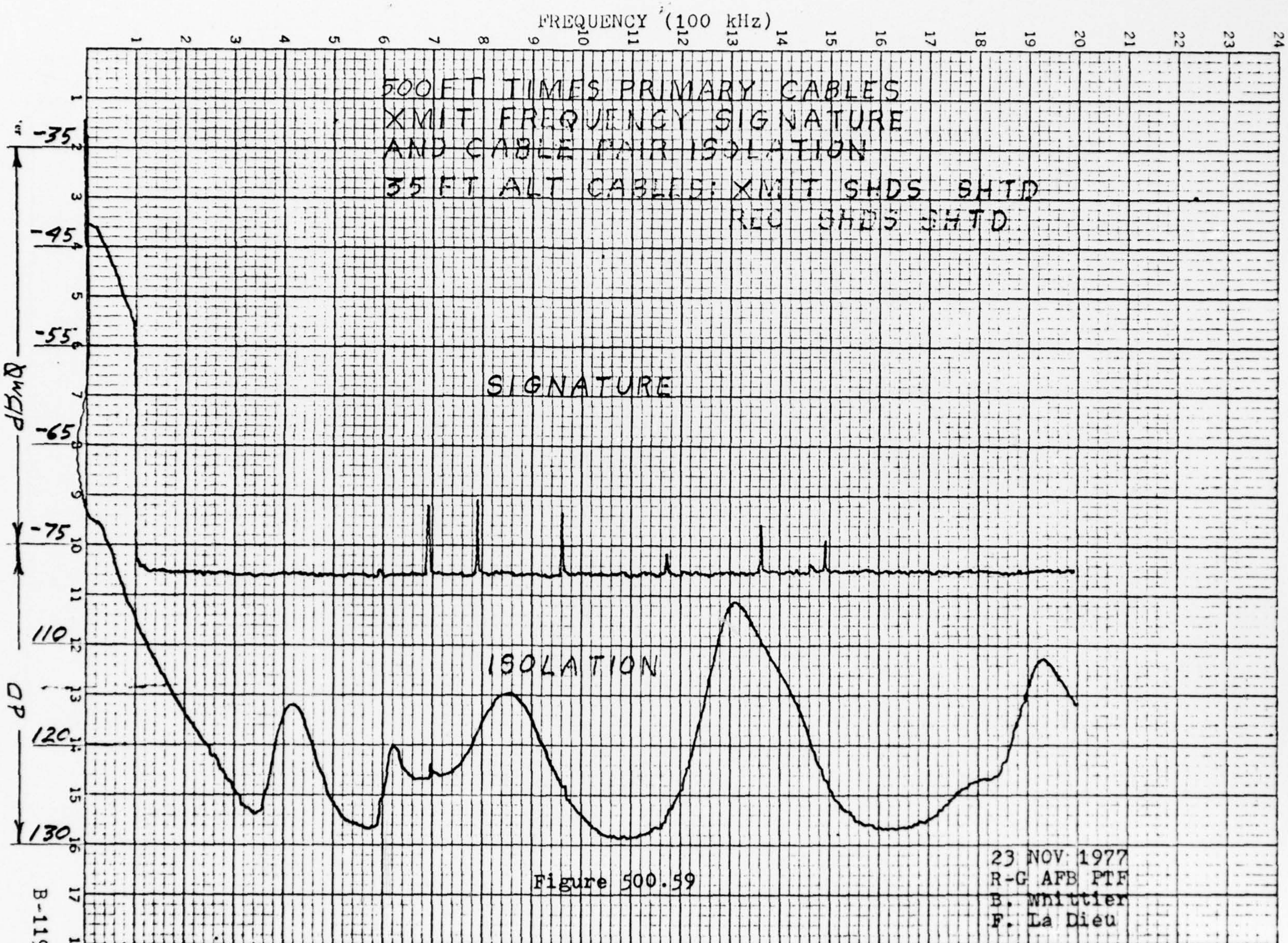


Figure 500.59

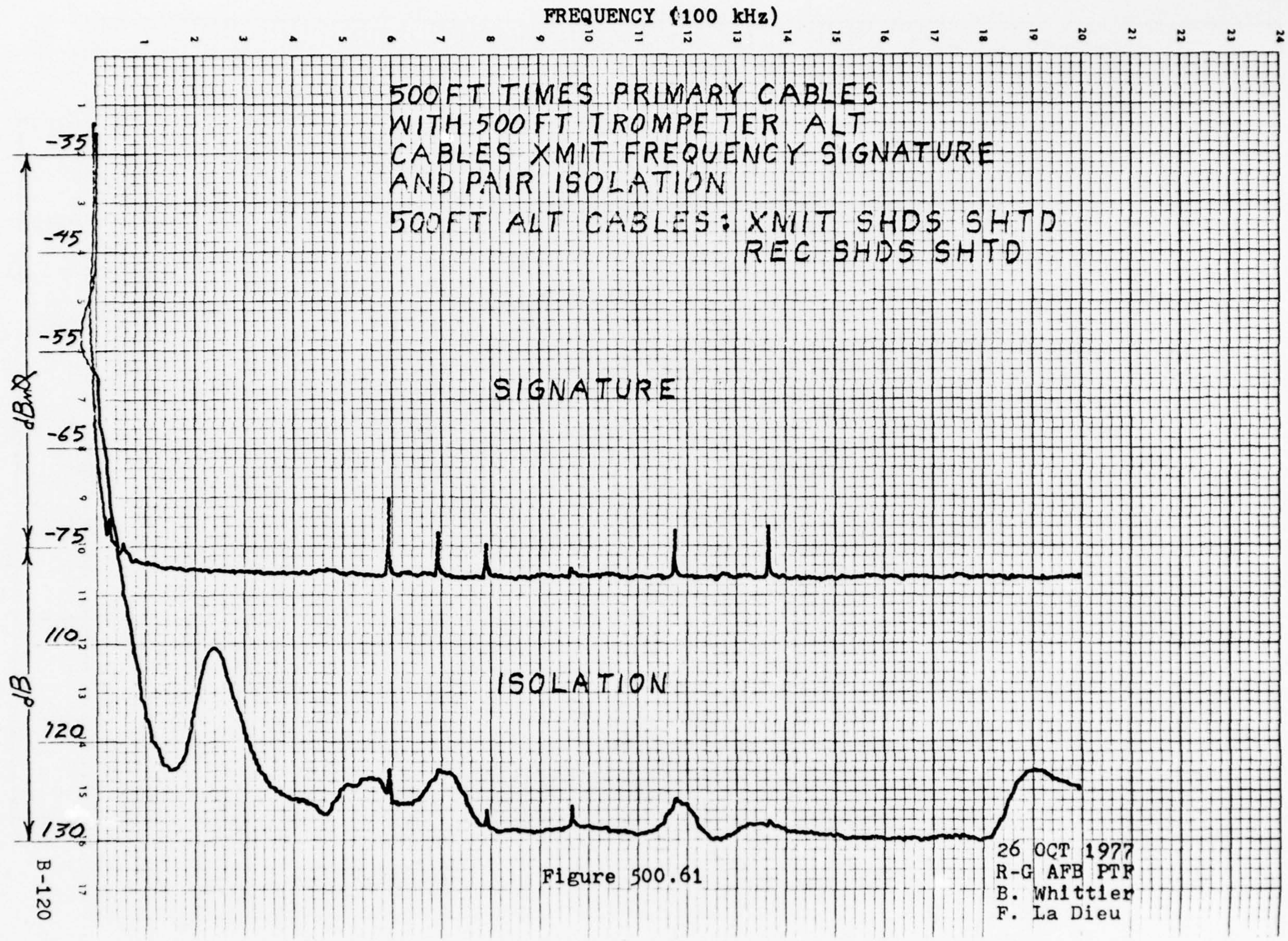


Figure 500.61

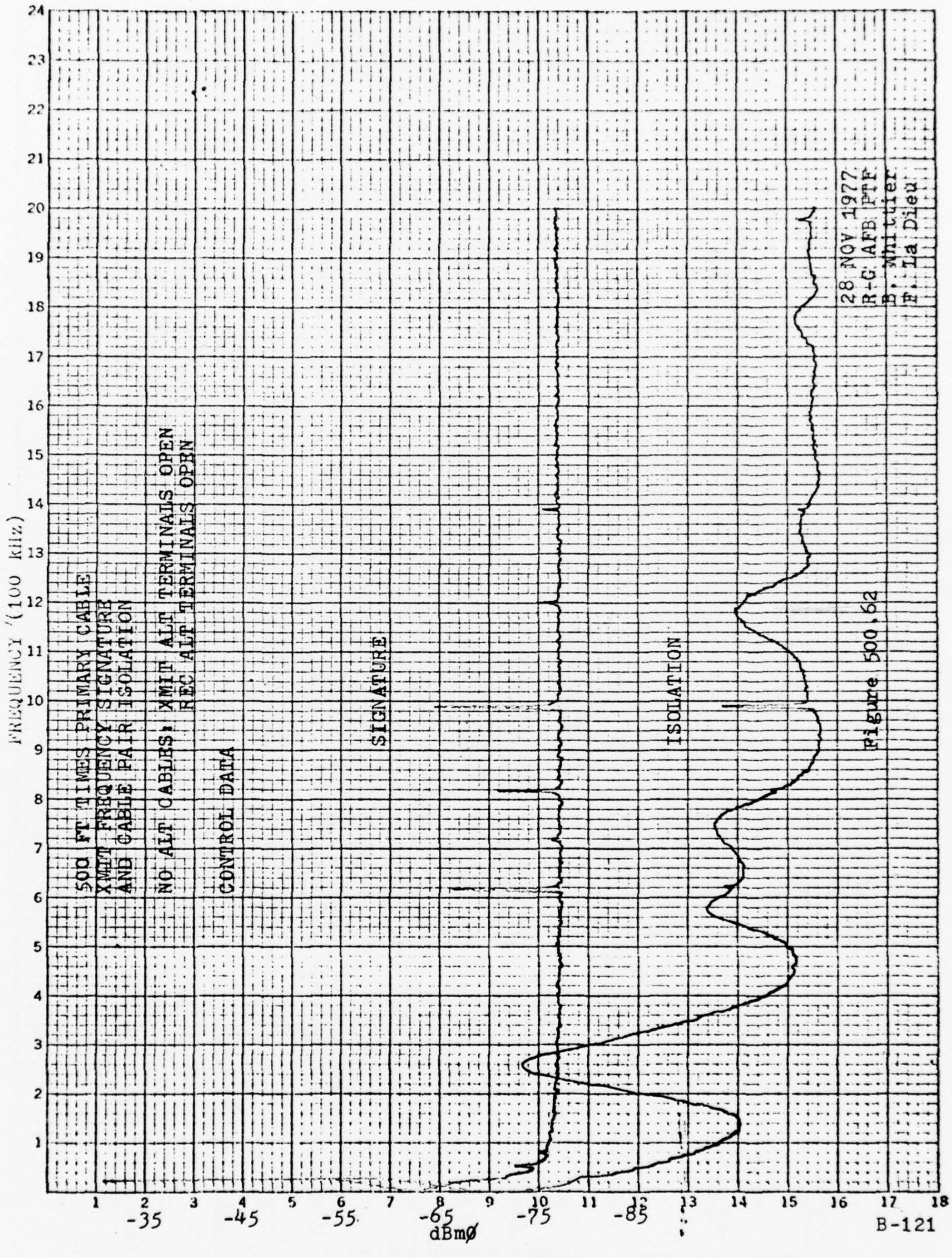


Figure 500.62

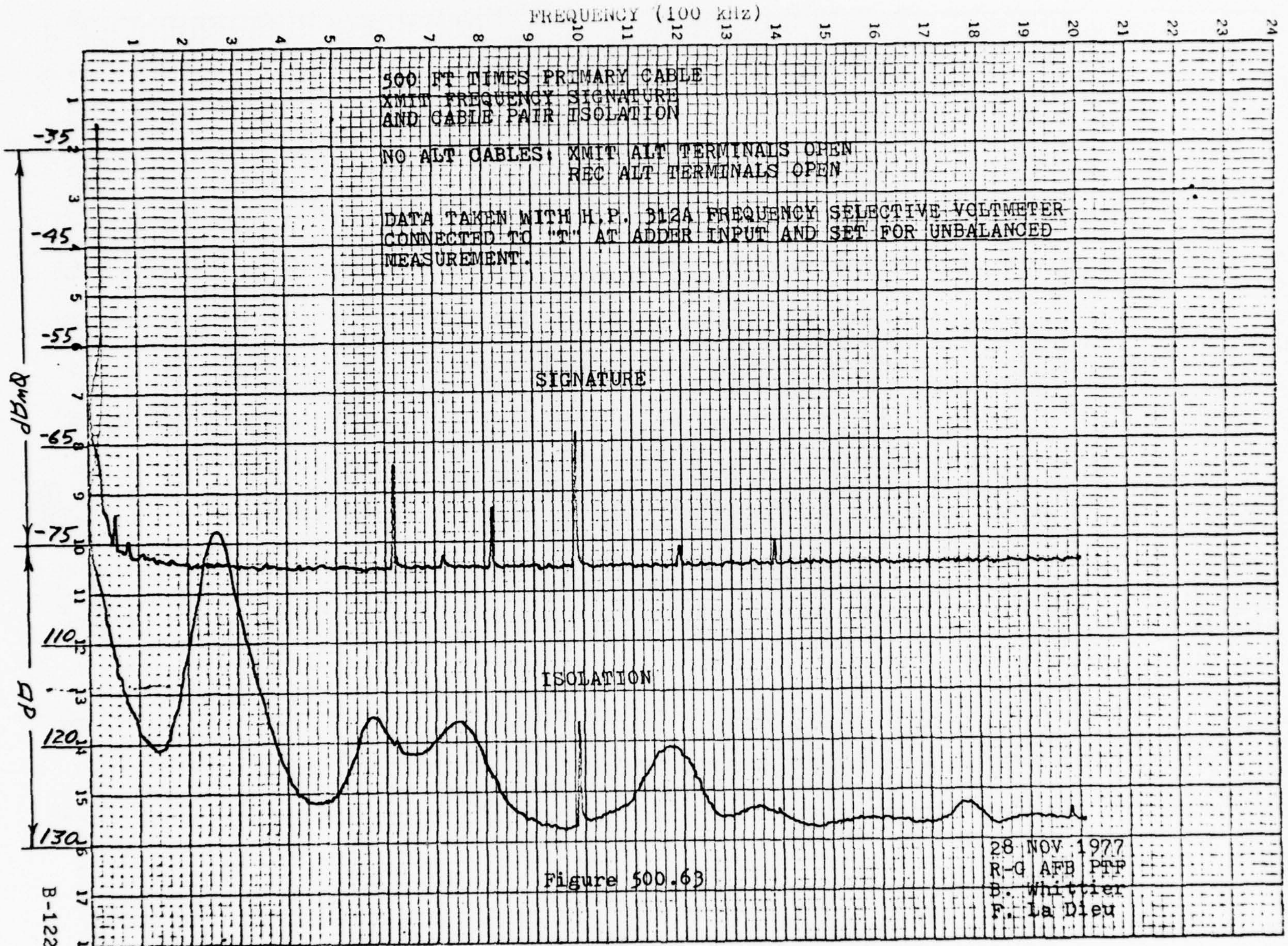


Figure 500.63

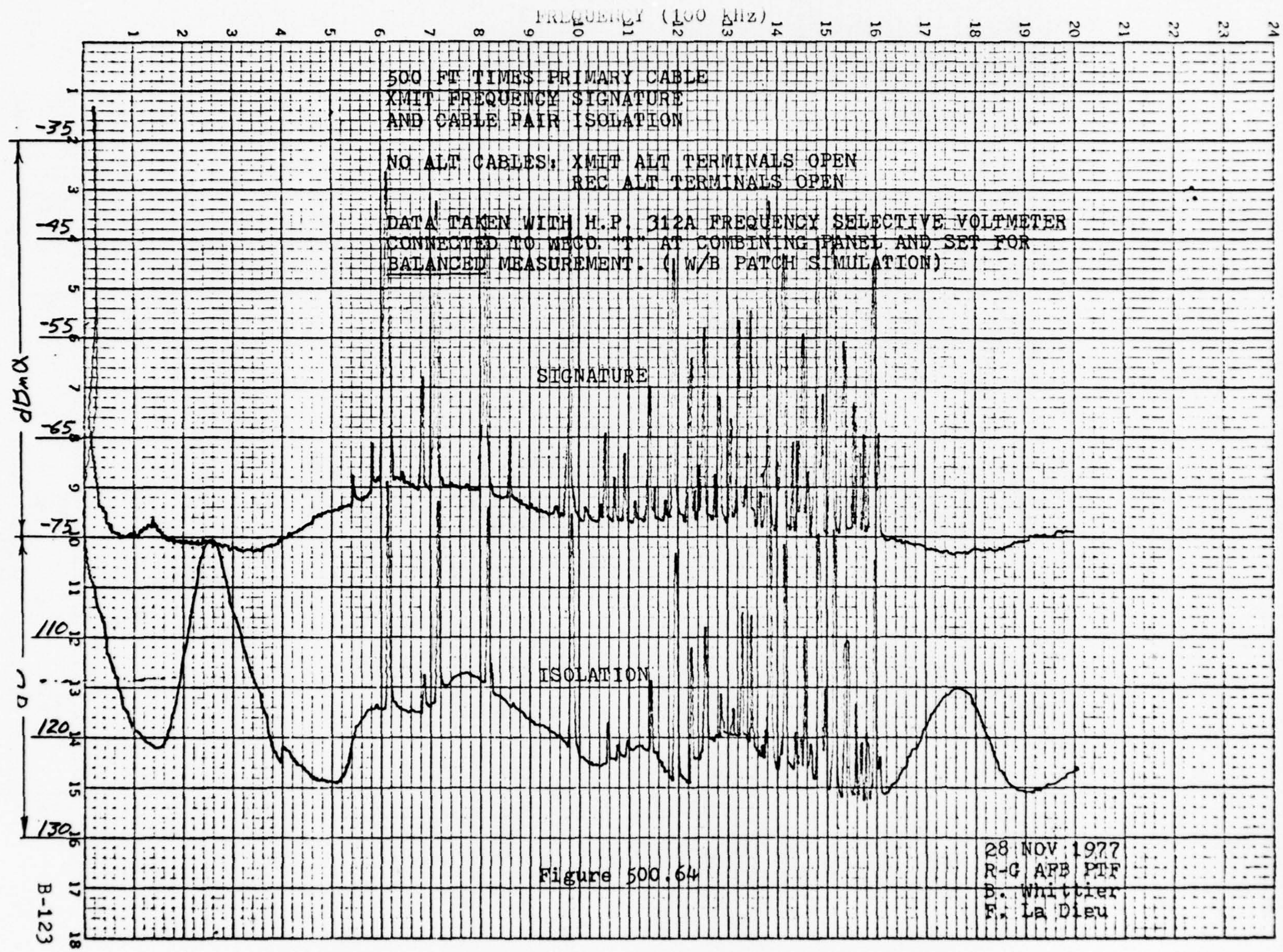


Figure 500.64

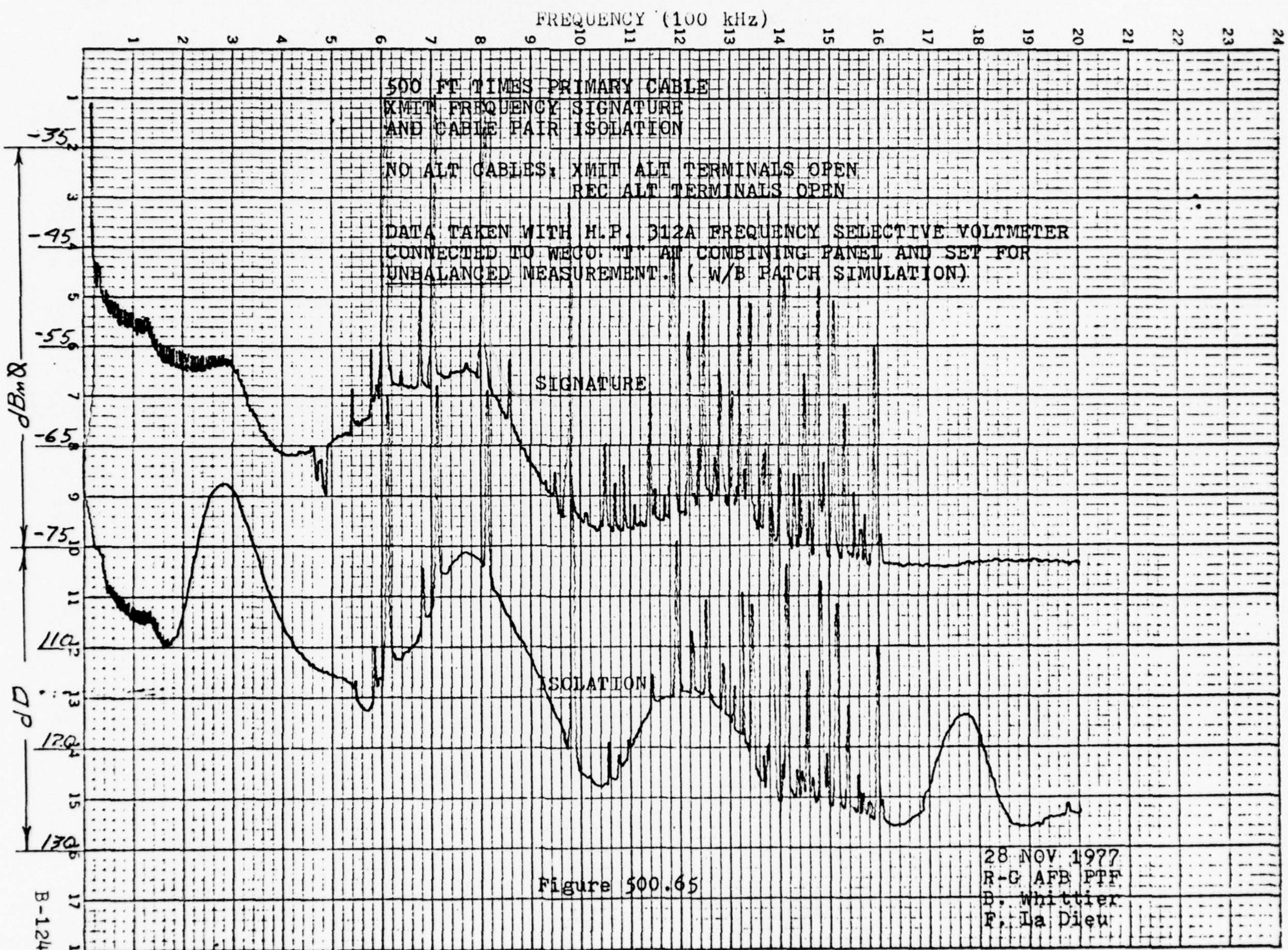
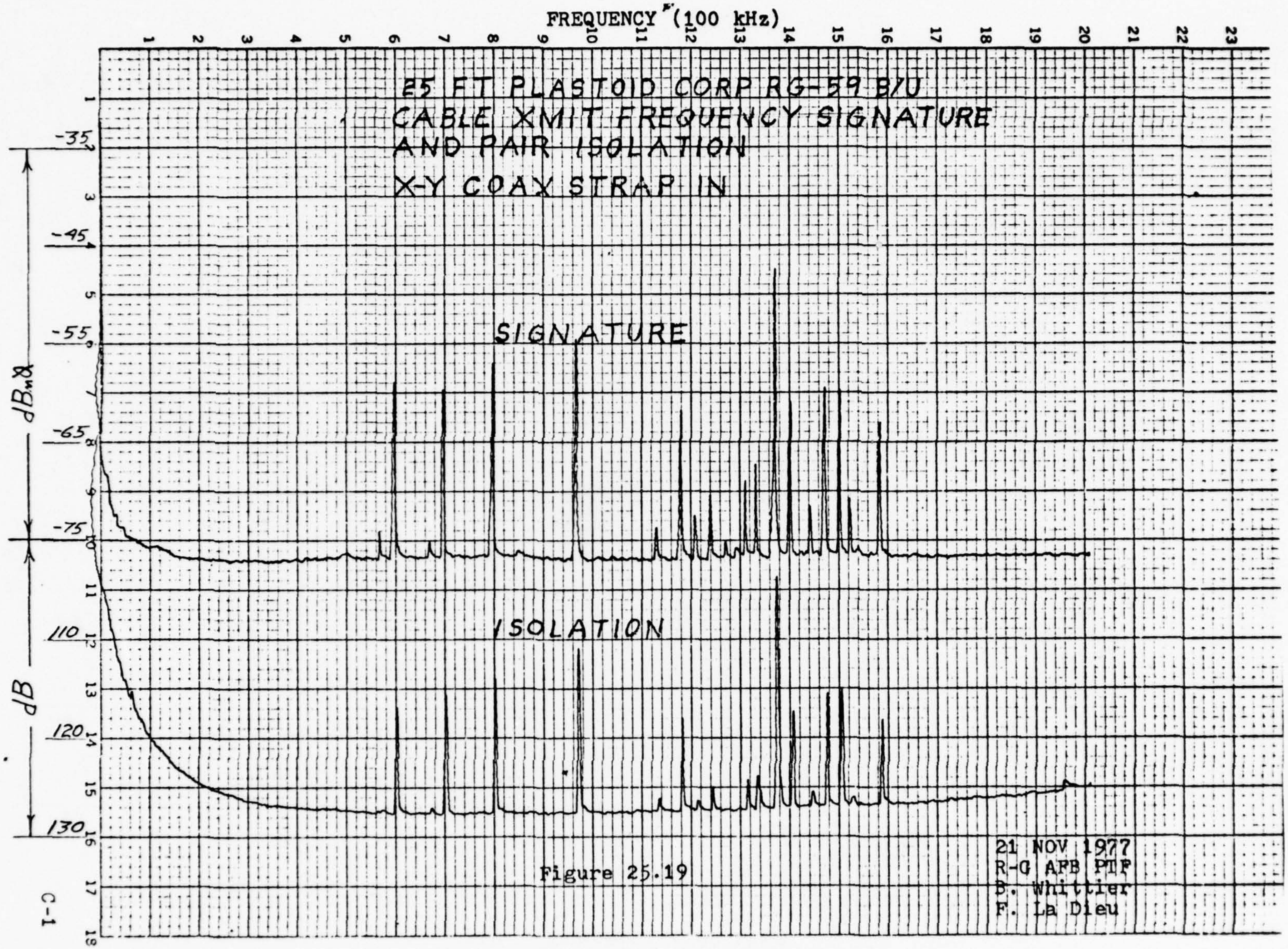


Figure 500.65

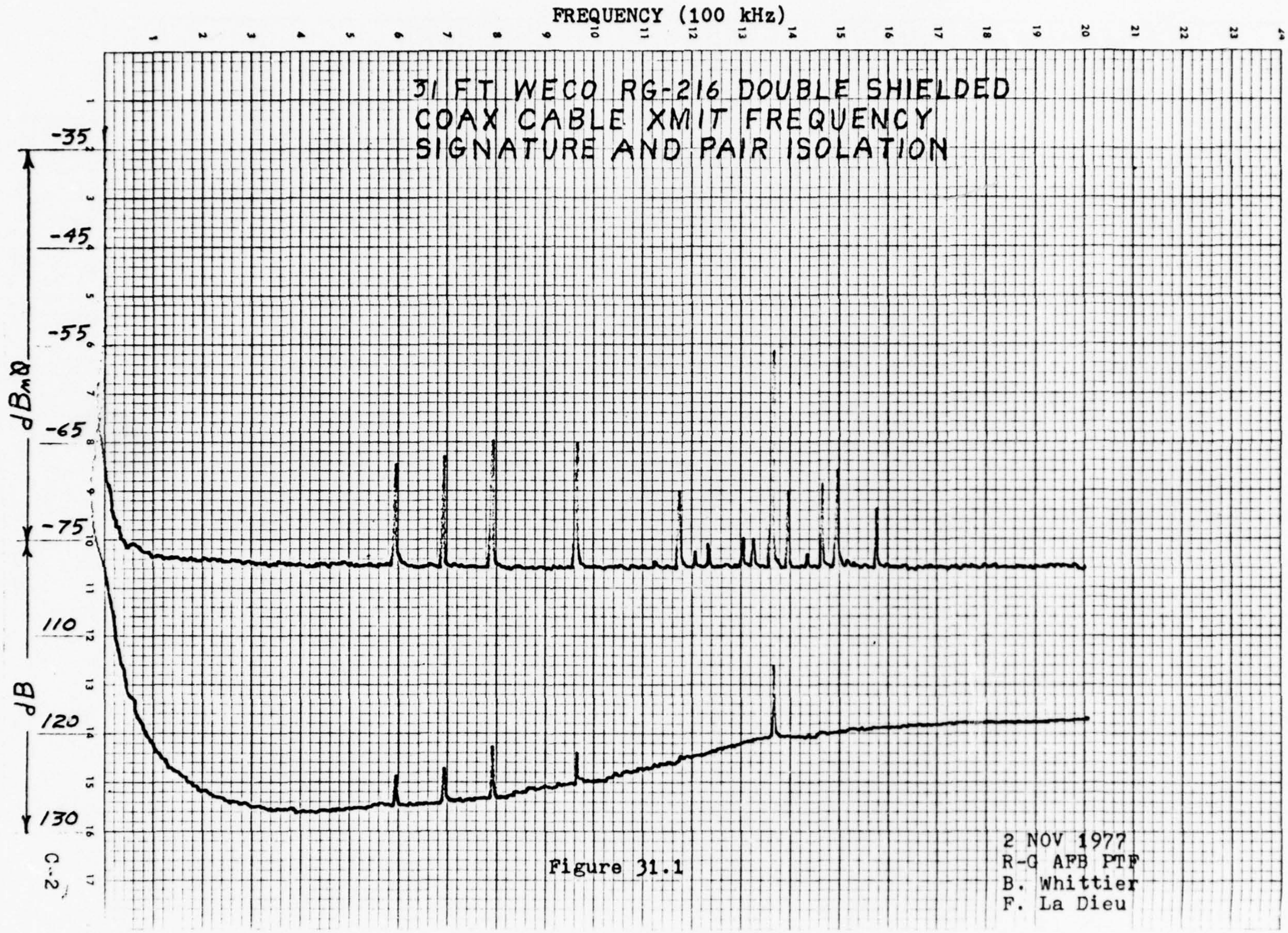
APPENDIX C

TEST DATA FOR
COAX BASEBAND CABLE PLANTS



FREQUENCY (100 kHz)
25 FT PLASTOID CORP RG-59 B/U
CABLE XMIT FREQUENCY SIGNATURE
AND PAIR ISOLATION
X-Y COAX STRAP IN
SIGNATURE
ISOLATION
dBmQ
dB
-35
-45
-55
-65
-75
110
120
130
21 NOV 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 25.19



FREQUENCY (100 kHz)
31 FT WECO RG-216 DOUBLE SHIELDED
COAX CABLE XMIT FREQUENCY
SIGNATURE AND PAIR ISOLATION
-35
-45
-55
-65
-75
110
120
130
dBmO
dB
2 NOV 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 31.1

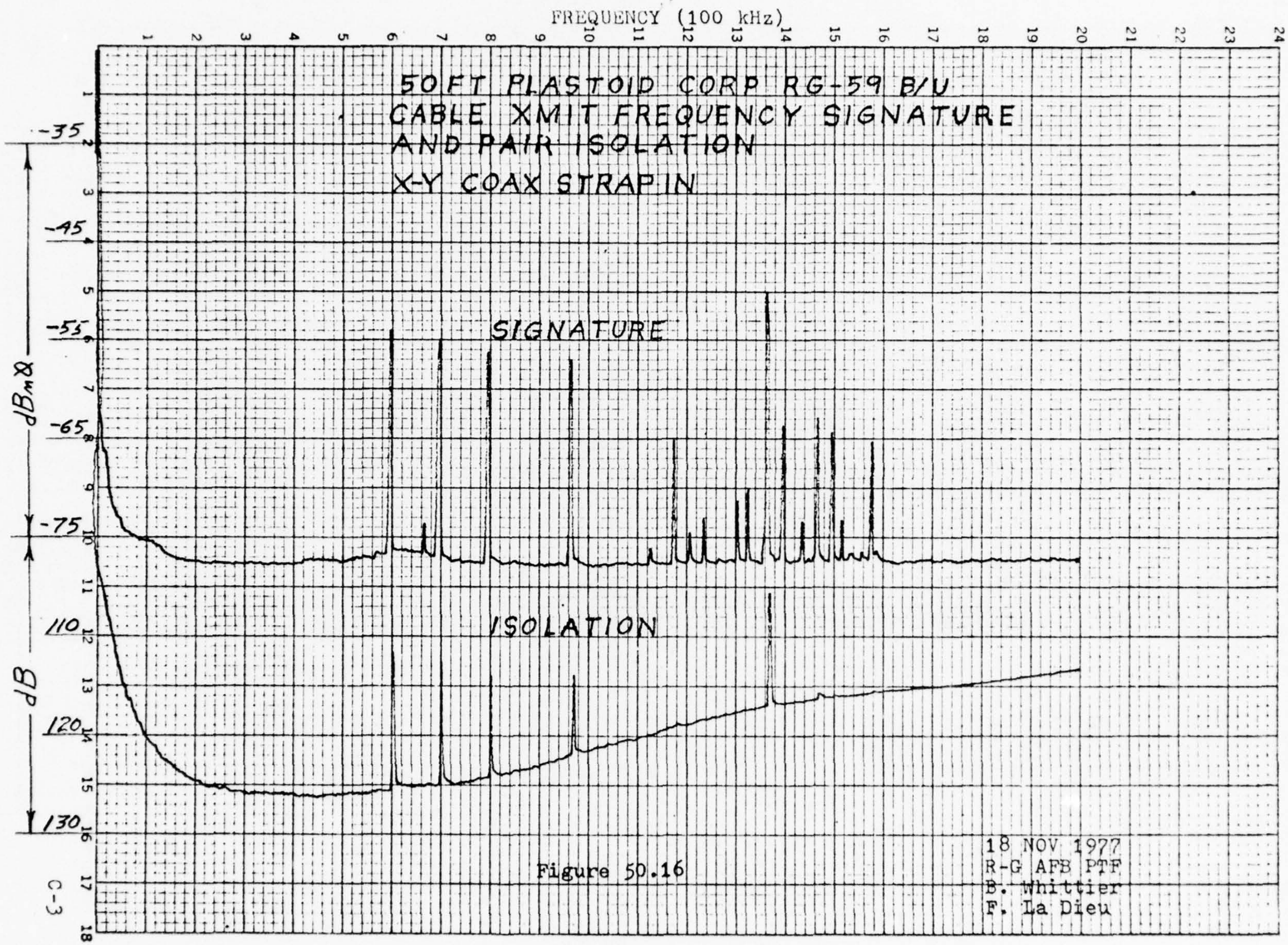

FREQUENCY (100 kHz)
50 FT PLASTOID CORP RG-59 B/U
CABLE XMIT FREQUENCY SIGNATURE
AND PAIR ISOLATION
X-Y COAX STRAPIN
SIGNATURE
ISOLATION
dBmØ
dB
-35
-45
-55
-65
-75
110
120
130
18 NOV 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 50.16

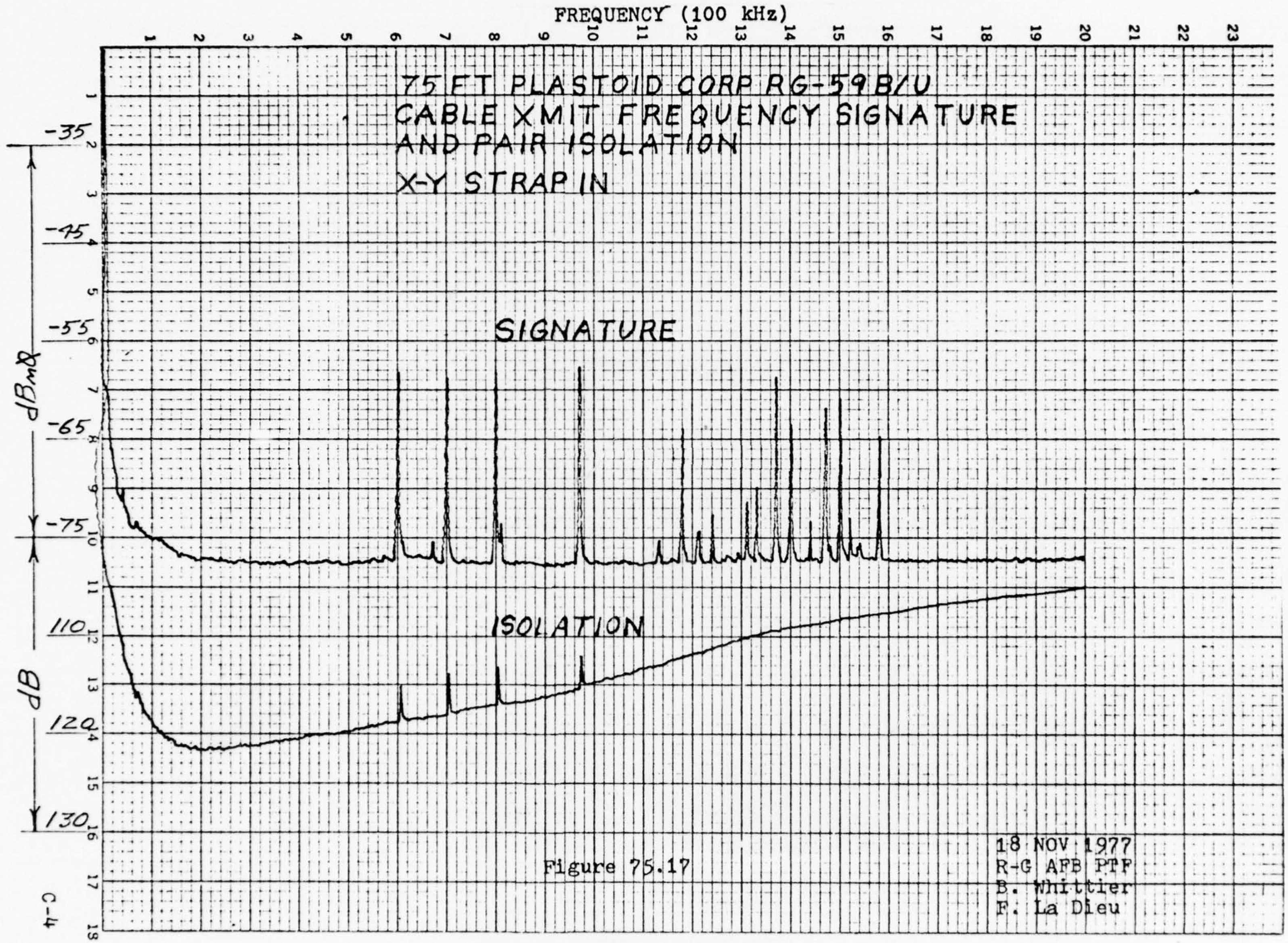

FREQUENCY (100 kHz)
75 FT PLASTOID CORP RG-59B/U
CABLE XMIT FREQUENCY SIGNATURE
AND PAIR ISOLATION
X-Y STRAP IN
SIGNATURE
ISOLATION
-35
-45
-55
-65
-75
dBmO
110
120
130
dB
18 NOV 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.17

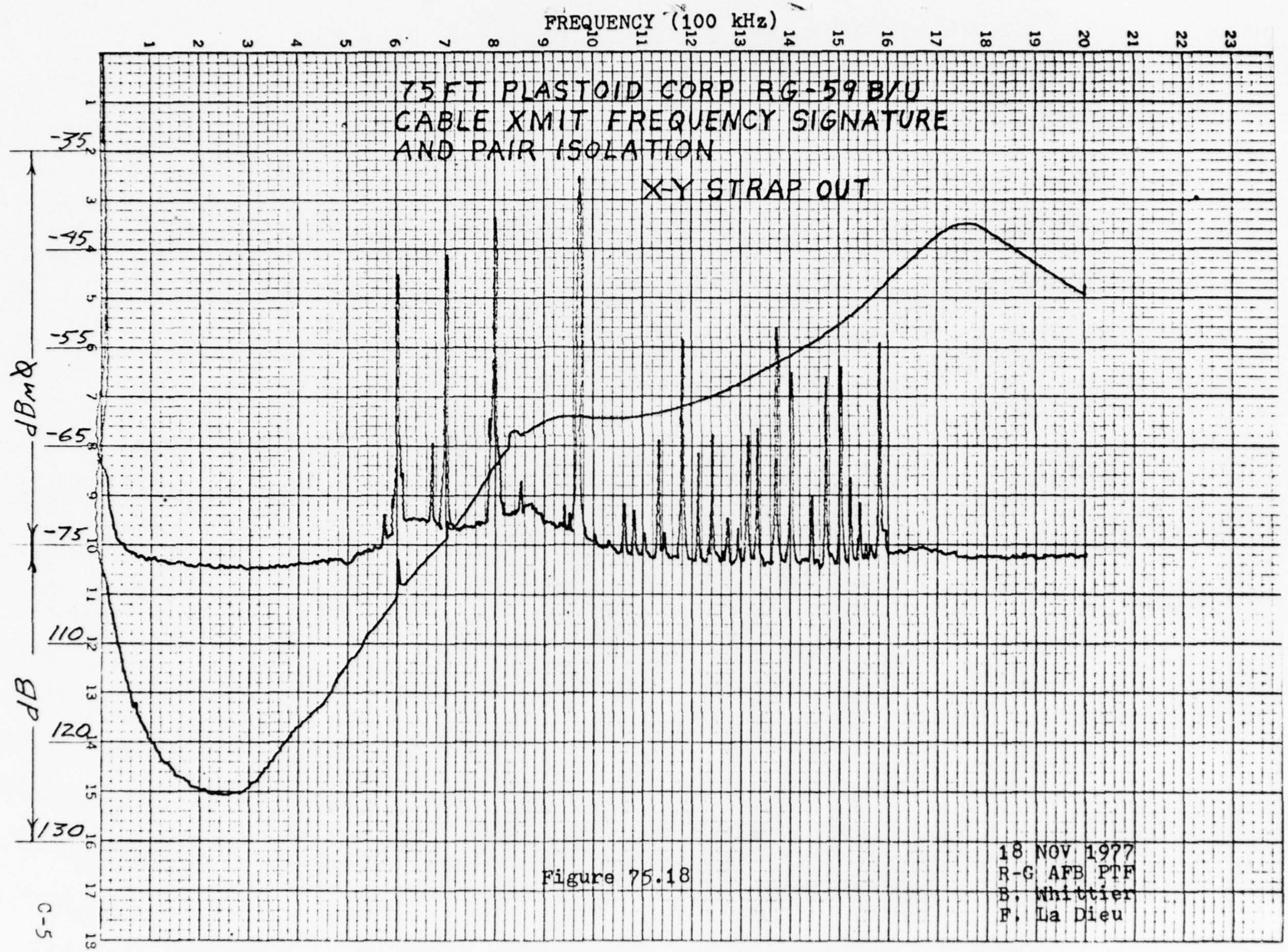

75 FT PLASTOID CORP RG-59 B/U
CABLE XMIT FREQUENCY SIGNATURE
AND PAIR ISOLATION
X-Y STRAP OUT
FREQUENCY (100 kHz)
dBmΩ
dB
-35
-45
-55
-65
-75
110
120
130
18 NOV 1977
R-G AFB PTF
B. Whittier
F. La Dieu

Figure 75.18

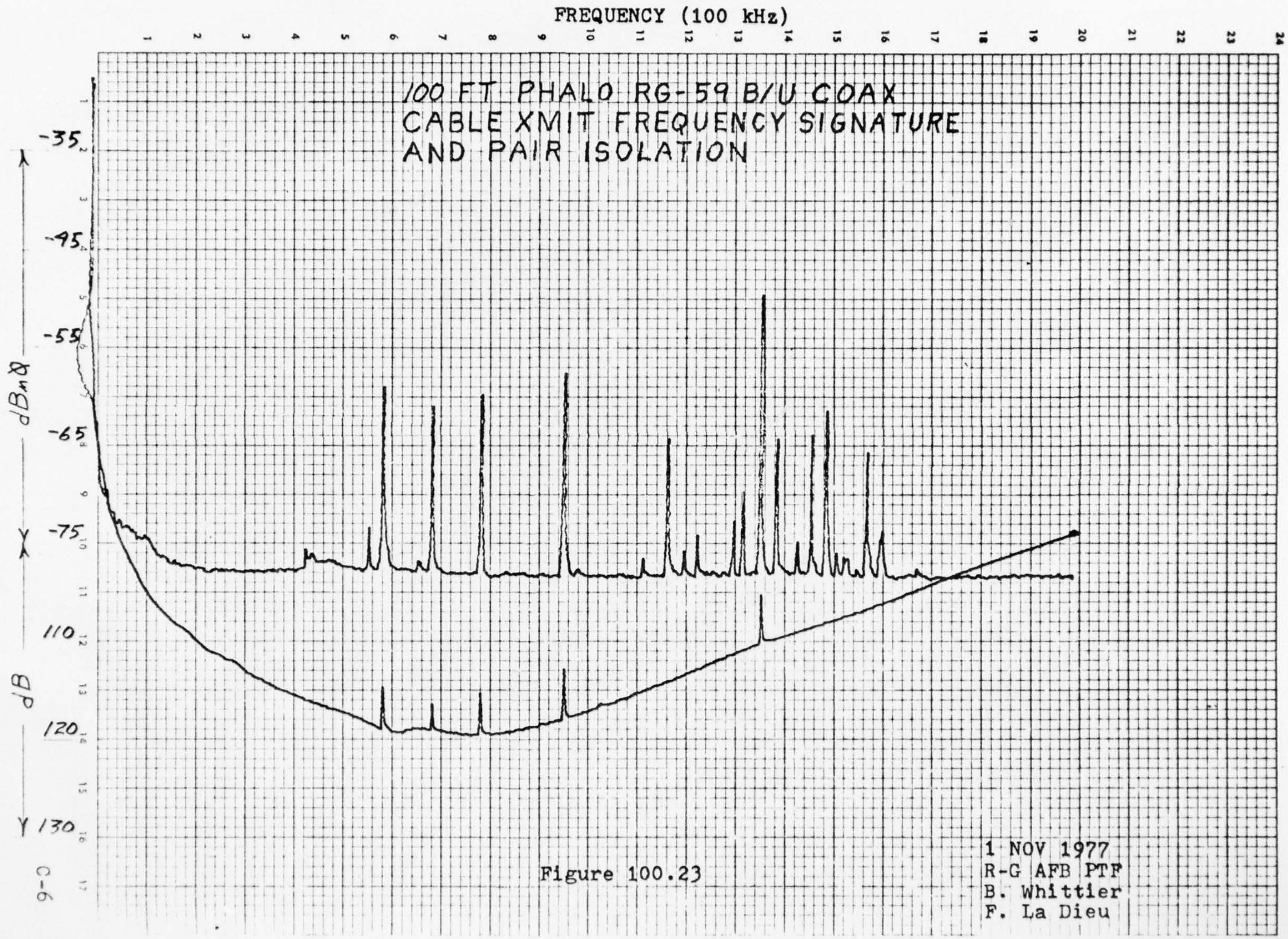


Figure 100.23

APPENDIX D

DATA AND REPORTS ON BALANCED BASEBAND CABLE PLANT INVESTIGATIONS

EETTW/La Dieu/3907/bc/8 Aug 77

08 AUG 1977

EETTW

Excessive Radio Frequency Interference (RFI) on Baseband Cable Installation for Task 44 UK (Your Ltr, 11 Jul 77)

AFCS/EPPD

1. An evaluation of the baseband cable problems addressed in ECA/LG letter, 7 Jun 77 and 2130 CG/DOY 011400Z Jun 77 was completed 21 Jul 77. A report is being prepared and will be distributed to all concerned parties on completion.

2. Interim information is provided below for guidance:

a. A special test and evaluation team composed of engineering and installation personnel selected from all concerned AFCS activities conducted RFI and noise performance comparison tests at RAF Croughton 5 Jul through 21 Jul 77. The availability of a balanced baseband cable plant installed and tested under Capt Lemelins' supervision provided the team with an excellent opportunity to test and evaluate objectively the relative performance of balanced and unbalanced cable plants under test bed conditions. MSgt Thebeau, 2130 CG Systems Office, assisted the team throughout testing to insure the integrity of the balanced cable plant as previously configured and tested and reported on in 2130 CG/DOY 011400Z Jun 77. The conclusions reached by the team were based on observed test results and were fully agreed upon. On conclusion of testing, the team provided a briefing to the 2130 CG commander and his staff. The elements of this briefing are cited as follows:

(1) Both balanced and unbalanced cable plants were tested prior to troubleshooting of the unbalanced cable plant installation to provide a data baseline for later comparison with a correctly installed unbalanced cable plant. Each exhibited degraded noise performance. Whereas the unbalanced cable plant degradation was readily observable, the degradation suffered by the balanced cable plant was reduced sufficiently that substandard performance could only be shown by comparison with a properly installed balanced cable plant or recognized through previous experience in balanced cable plant testing. (Note para 3 of HQ AFCS/EP 061505Z Jun 77). The danger posed here by the balanced cable plant is that it reduces the effects of improperly installed cabling yet precludes attainment of optimum baseband interface performance. This type of low grade degradation can exist indefinitely with poor system performance attributed to radio, multiplex or path problems.

(2) Actual troubleshooting of the unbalanced cable plant was accomplished by use of an ohmmeter and visual inspection. Other test equipment such as test oscillator, frequency selective voltmeter and spectrum analyzer were used to obtain baseline data for comparison testing of the two types of cable plants.

(3) Defects in the cable plant were isolated to cable connections in the multiplex baseband combining panel. The outer shield of the triax cables were not grounded; preparation and dressing of the triax cable connections to the combining panel terminals required reworking to insure maximum cable isolation and good mechanical strength.

(4) The defective cables were found to be common to both balanced and unbalanced cable plants. On correction of these defects, both cable plants showed equally high performance levels.

(5) Examination of the baseband frequency spectrum in each cable plant showed the RFI rejection of both balanced and unbalanced cable plants to be frequency dependent. That is, neither type of cable plant showed a consistant improvement over the other in RFI rejection across the baseband spectrum. The overall RFI performance of the two cable plants averages out when the full baseband spectrum is considered.

(6) Comparison of relative merit and installation requirements for the balanced and unbalanced cable plants were made by the team. The conclusions reached were:

(a) Proper installation of balanced cable plants requires the same level of training and degree of care as installation of unbalanced cable plants.

(b) The reliability of a balanced cable plant is reduced by the increased population of connectors and addition of transformers.

(c) Based on all relative performance tests made to date (see atch 1, 2, and 3), there is no justification for further expenditure of funds for design, development and installation of balanced baseband cable retrofit packages for AN/UCC-4/radio interfaces.

b. The widespread belief that there have been balanced cable plants installed on the Feldberg-Langerkopf link that have shown superior RFI and noise performance to unbalanced cable plants was conclusively disproved to the satisfaction of all interested parties through exhaustive tests conducted at Feldberg and Langerkopf. It appears that the circumstances surrounding these tests and the results thereof did not receive sufficient dissemination to the field. Therefore, a short history is provided here along with attachments to rectify this situation: On 30 Jan 1975, a memo prepared by MSgt Cathcart "proving the superiority" of balanced baseband cables over unbalanced baseband cables and detailing methods used to install the balanced

cablo plants in lieu of existing unbalanced cable plants was forwarded from Det 12-1945 CG to 1945 CG/DO. The justification for switching from the originally installed unbalanced cable plant to the balanced cable plants on this link was the excessive crosstalk thought to be taking place between the unbalanced cables. Subsequent testing of the balanced cable plant installed by MSgt Cathcart verified that its performance when evaluated in terms of Langerkopf received noise levels was better than the original unbalanced cable plant by an average of 2.32 dB (3KC Flat), however, when the unbalanced cable plant was installed correctly, the unbalanced cable plant performed on average 1.9 dB (3KC Flat) better than the balanced system. What is important to note here is a fact not given due recognition. That is, that the balanced cable plant was operated with a transmit level of plus 1.5 dBm whereas the unbalanced system operated at a transmit level of minus 20 dBm. This difference in transmit level by itself should have afforded the balanced cable plant a 21.5 dB improvement in crosstalk rejection and noise performance advantage over the unbalanced cable plant. As this improvement was never realized (this is shown by the crosstalk and noise data taken at Langerkopf), it serves to emphasize the poor isolation characteristic normally observed in balanced cable plants. Complete documentation of the forementioned testing was distributed by TSgt Engel, Det 12-1945 CG on 14 Aug 75, Baseband Cable Configurations. The testing of these cable plants was fully supported by ECA/LG/EP and was accomplished by direction of AFCS/EPE. A report on the results of this testing is contained in ECA/EPE 081520Z Aug 75 (atch 2).

3. A project to develop FDM baseband cable plant E&I standards has been established by 1842 EEG/EETTW. This project provides for:

a. Further investigation into AN/UCC-4 multiplex/radio interfaces with the aim of substantially reducing or eliminating the effects of RFI on mission channels. Compatibility of FDM and digital baseband cable plants will be determined.

b. Preparation of definitive E&I standards which will insure the correct installation of baseband cables in a standard configuration.

c. Preparation of a technical report on baseband cable plant interfaces: installation, maintenance and testing.

As the technical expertise for baseband cable plants resides in ECA/LG and 1842 EEG, the successful accomplishment of this project will require ECA support during certain phases of this effort to insure that the products produced are technically acceptable, supportable and in consonance with ECA requirements. The scope and potential impact of this project on ECA mission necessitates that ECA be kept abreast of its progress. An exchange of information/recommendations with the

project office is encouraged.

4. ECA/LG observation that implementation of fiber optics cable plants is many years down the road is realistic. A cautious approach to acceptance of this type of fix as a cure-all is in order. Use of fiber optics in an analog interface for FDM multiplex and radios is a new area of application. Until a prototype optical cable plant is available for testing, an assessment of its acceptability cannot be made. The presently installed unbalanced cable plants are virtually noise free with only a limited number of channels affected by near end RFI. The sole advantage in use of a fiber optics cable plant is to eliminate near end RFI (distant end RFI will still affect local channels to same degree). Recent testing of baseband cable plants at RAF Croughton suggests that RFI is being picked up in the multiplex combining panel as well as induced in baseband cables. Should this be verified, a fiber optics cable plant will provide only a partial solution to the RFI problem.

5. In summary, it is felt that sufficient testing of balanced versus unbalanced cable plants has been performed to establish that no significant improvement in baseband cable performance can be expected from conversion of existing unbalanced plants to balanced configurations. Use of available monetary and technical resources can best be used to insure proper installation, understanding and maintenance of the existing cable plants. Full cooperation of all AFCS elements will be needed to achieve this end. As improvements in existing plants are developed and alternate baseband interface methods become available they will receive careful evaluation with area participation requested prior to implementation in the field.

SIGNED

WAYNE F. WILSON
Chief, Transmission Sys Br

3 Atch
1. ECA/EPZ 081405Z Apr 75
2. AFCS/EPE 161450Z Jul 75
3. Det 25-1945CG 251500Z Jul 77

Cy to: AFCS/EPE

ROUTINE

PIA 00243 206 1857:41

RITUZYUW RHFRAAB4534 2061550-UUUU--RUKTAAN.
ZNR UUUUU
R 251500Z JUL 77 251500Z
FM DET 251945CG LANGERKOPF GE/CC
TO RUKTAAA/1842EEG RICHARDS GEBAUR AFB MO/EET
INFO RUKTAAA/PG AFCS RICHARDS GEBAUR AFB MO/EP/LC
ZEN/ECA RAMSTEIN AB GE/LG/XRQ
RUEDBJA/1844EES GRIFFISS AFB NY/EPEG
RUDONAA/2130CG RAF CROUGHTON UK/CSS
RUCLEBA/1839 EIG KEESLER AFB MS/EPE
RUFLOJA/1945CG RHEIN MAIN AB GE/CC
BT
UNCLAS
SUBJ: EXCESSIVE RFI AT RAF CROUGHTON
TASK 44(UK) SCHEME 016944LO
REF: A. HQ AFCS/EP 061505Z JUL 77
B. ECA/LG 231230Z JUL 77
C. ECA ENGINEERING REPORT ON SCOPE COMM BASEBAND
CABLE PLANTS, ENGINEERING INSTALLATION, AND TESTING 5 SEP 1975
1. INVESTIGATION AND TESTING OF TASK 44 BASEBAND CABLE PLANTS AT RAF
CROUGHTON AND RAF UXBRIDGE DURING 5 THRU 21
JULY 1977 RECONFIRM FINDINGS AND INSTRUCTIONS PROVIDED
IN REF C:
PAGE 2 RHFRAAB4534 UNCLAS
A. TRIAX (UNBALANCED) CABLE PLANTS PROVIDE EXCELLENT PERFORMANCE
WHEN INSTALLED IAW INSTRUCTIONS PROVIDED.
B. BALANCED CABLE PLANTS PROVIDE NO IMPROVEMENTS IN RFI OR NOISE
PERFORMANCE OVER UNBALANCED CABLE PLANT PERFORMANCE.
C. BALANCED CABLE PLANTS MUST BE PROPERLY INSTALLED TO ACHIEVE
THE SAME LEVEL OF PERFORMANCE OBTAINED FROM UNBALANCED CABLE PLANTS.
D. IMPROPERLY INSTALLED CABLE PLANTS MASK INSTALLATION DEFESTS
WHICH MUST BE CORRECTED TO ACHIEVE THE HIGH PERFORMANCE A CORRECTLY IN-
STALLED CABLE PLANT PROVIDES.
2. DURING THE EVALUATION OF BALANCED VS. UNBALANCED CABLE PLANTS,
SUGGEST THAT ANY TESTING BE CONDUCTED UNDER CAREFULLY CONTROLLED CON-
DITIONS. ANY DEFECT IN THE TEST INSTALLATION MAY LEAD TO FALSE PER-
FORMANCE INDICATIONS.
MR. STOECKLE SENDS.
BT
#4534
NNNN

1842 EEG - 3641

MESSAGE ROUTING INDICATOR

	AC	CC	CS	CSS	DA	DE	DO	DP	EP	FF	HC	HO	IG	JA	LG	OA	OI	SG	XP	IGZ	CSB	DOOI	COMM CEN	DOCP / DOCM	SUPVR NO.
ACTION									4																OPS NO.
INFO															2										

FCS FORM 1296, MAR 75 REVISED.

RTTUZYUW RHFRAAB3345 41425-UUUU--RUKTAAA.
ZNR UUUUU
R 231230Z JUN 77 231230Z
FM ECA RAMSTEIN AB GE/LG
TO RUKTAAA/HQ AFCS RICHARDS GEBAUR AFB MO/LG/DO/EP
INFO RUKTAAA/1842EEG RICHARDS GEBAUR AFB MO
RUEDPJA/1844EES GRIFFISS AFB NY/EPEG
RUCLLRA/1839EIG KEESLER AFB MS/EPE
RUDDNAA/2130CG RAF CROUGHTON UK/LGM/XRP
RUEDPJA/485EIS GRIFFISS AFB NY/EPT/EPIE
RUFLOJA/1945CG RHEIN MAIN AB GE/LGM
ZEN/DET 25 1945CG LANGERKOPF GE
BT
UNCLAS
SUBJ: EXCESSIVE RFI AT RAF CROUGHTON TASK 44 (UK) SCHEME C169A4LO
A. NCA/EPE 201930Z JUN 77
B. NCA/EPE 141900Z JUN 77
C. AFCS/DOY 141650Z JUN 77
D. 1842EEG 101400Z JUN 77
E. ECA/DOY 101434Z JUN 77
F. 2130CG/DOY 011434Z JUN 77
G. DCA NOTICE 310-70-1 SEP 76
PAGE 2 RHFRAAB3345 UNCLAS
H. AFCS/DO (S) LTR, 27 SEP 76, TEST REPORT DIGITAL EUROPEAN BACK-
BONE (DEB) VS ELECTRONIC WARFARE (EW).
I. ECA ENGINEERING REPORT ON SCOPE COMM BASE BAND CABLE PLANTS, ENGINEERING INSTALLATION AND TESTING (NOTAL).
J. ENG REPORT AFCS 1839 EI CP-EMC-75-59 INTERFERENCE TO AN/UCC-4 MULTIPLEX EQUIPMENT AT SELECTED SCOPE COMM SITES 25 AUG - 8 SEP 75 (NOTAL).
1. REFS E AND F HAVE PRESENTED OUR FINDINGS ON THE SUBSTANDARD PERFORMANCE NOTED IN THE TASK 44 UK SYSTEM. REFS C AND D ADDRESS NEAR TERM ACTIONS THAT CAN BE TAKEN TO CORRECT THE RFI CONDITIONS BEING NOTED. THE COMMENTS CONTAINED IN REF C THAT 2130CG TEST RESULTS MAY BE INVALID DUE TO TRIAX INSTALLATION DEFICIENCIES, WHICH ARE DULY NOTED, SUBSTANTIATE OUR ANALYSIS THAT TRIAX CABLE INSTALLATIONS MUST BE ABSOLUTELY PERFECT AND REQUIRE PRECISE MEASUREMENTS. THE END RESULT: CUSTOMIZING EACH INSTALLATION TO MINIMIZE RFI EFFECTS. THIS PROCESS MUST BE REPEATED WITH ANY CHANGES TO INSTALLED FACILITIES, THIS FACT BEING A DRIVING FACTOR FOR OUR RECOMMENDATION TO REVERT TO THE USE OF BALANCED CABLES AND SUPPORTS OUR POSITION.
PAGE 3 RHFRAAB3345 UNCLAS
3. THE LESSONS LEARNED IN SCOPE COMM (TASK 21: 44 GERMANY & 55) AND TRIAX CABLE INSTALLATION TECHNIQUES DEVELOPED THEREFROM

BEST AVAILABLE COPY

1841 EEG -3005

MESSAGE ROUTING INDICATOR

AGENCY	AC	CC	CS	CSS	DA	DE	DO	DP	EP	FF	HC	HO	IG	JA	LG	OA	OI	SG	XP	IGZ	CSO	DOOM	COMM CEN	DOCR DOCM	SERV NO.
ACTION															/										
INFO		/					/		/																

HAVE APPARENTLY FAILED TO PRODUCE A USABLE INSTALLATION IN TASK 44 (UK). AS WITH PREVIOUS SCOPE COMM CLEAN UP EFFORTS, WE ARE CONFIDENT THAT THE RFI PROBLEMS NOW BEING NOTED AT TASK 44 UK SITES COULD BE RESOLVED USING THE EXPERTISE OF MR. STOECKLE AND OTHER O/M RESOURCES. WE DO, HOWEVER, OFFER STRONG OBJECTION TO AGAIN BEING REQUIRED TO RESOLVE THESE RECURRING ENGINEERING DEFICIENCIES. IT IS, WE BELIEVE, A DEFICIENCY THAT CAN BE BEST CORRECTED BY REENGINEERING AND INSTALLATION OF BALANCED COAX CABLES. EARLY ACTIVATION OF TASK 44 (UK) IS OF SPECIAL CONCERN FOR THIS THEATER AS IT ENHANCES COMMUNICATION CAPABILITIES, IS ESSENTIAL FOR INTERFACE WITH THE HST AT CROUGHTON AND WILL SIGNIFICANTLY REDUCE DIFFICULT SUPPORT REQUIREMENTS FOR MARCONI/AT&E EQUIPMENT. WE MUST, HOWEVER, TAKE THE POSITION THAT STANDARD INSTALLATION TECHNIQUES MUST INSURE QUALITY SERVICE AND NOT REQUIRE SPECIALIZED CORRECTIVE ACTIONS TO ACHIEVE THE PERFORMANCE STANDARDS FOR WHICH THE SYSTEM WAS DESIGNED. WE BELIEVE THE 2130CG TEST RESULTS ARE VALID AND SERVED TO REEMPHASIZE THE RFI PROBLEMS ASSOCIATED WITH UNBALANCED TRIAX

PAGE 4 RUFRAAA3345 UNCLAS

CABLES. THE RFI PROBLEM WITH TRIAX CABLE INSTALLATION HAD PREVIOUSLY, AND HAS AGAIN, BEEN VERIFIED AND WHILE CORRECTABLE TO VARYING DEGREES, WE BELIEVE THE TOTAL SOLUTION RESTS WITH THE USE OF BALANCED CABLES.

4. BEFORE WE COMMIT O/M RESOURCES TO THE CORRECTION OF THE DEFICIENCY, NCA/AFCS SHOULD FIRST VALIDATE THAT THE INSTALLATION HAS BEEN ACCOMPLISHED IAW REF I/J. SHOULD IT REMAIN NECESSARY FOR ECA TO PROVIDE ASSISTANCE, AND TOTAL CORRECTION/ELIMINATION OF RFI ON TRIAX CABLES IS NOT ACHIEVED, OUR RECOURSE MUST BE TO CITE EXCEPTIONS ON ACCEPTANCE DOCUMENTS FOR FOLLOW-ON CORRECTIVE ACTION BY NCA/AFCS. AND IF ECA ASSISTANCE IS REQUIRED, WE FEEL IT SHOULD BE PROVIDED TO THE ENGINEERING/INSTALLATION AGENCY IN COOPERATION WITH AN ON-SITE ENGINEER.

BT

#3345

NNNN

ROUTINE

ROUTINE 302

<TTUZYUW RUFFECA1062 0981546-UUUU--RUKTAAA.
ZNR UUUUU
R 081405Z APR 75
FM ECA LINDSEY AS GER/EPZ
TO AFCS RICHARDS GEBAUR AFB MO/EPECR/EPPD/EPP/OA
BT
UNCLAS
SUBJ: REPLACEMENT OF TASK 21 ENGLAND BASEBAND CABLES AT HILLINGDON, BARKWAY, WETHERSFIELD AND MARTLESHAM HEATH
REF: TELECOM MR. WALDRON, AFCS/EPEC, AND MR. LADIEU, ECA/EPZ
1. NEW BASEBAND CABLE INTERFACES REPLACING PREVIOUSLY USED COMPOSITE CABLES HAVE BEEN INSTALLED AT HILLINGDON, BARKWAY, WETHERSFIELD AND MARTLESHAM HEATH. THIS ACTION HAS CLEARED NUMEROUS BASEBAND CABLE PLANT DISCREPANCIES, PROVIDED ENVIRONMENTAL PROTECTION FOR CABLES, ELIMINATED 75/124 OHM IMPEDANCE MATCHING TRANSFORMERS AND SIGNIFICANTLY IMPROVED THE NOISE PERFORMANCE OF THE HILLINGDON NORTH AND EAST SYSTEMS.
2. THE NEW BASE BAND INSTALLATION UTILIZES TROMPETER TRC-75-2 75 OHM TRIAX CABLE AND PROVIDES FOR DIRECT 75 OHM CABLE INTERFACE BETWEEN MULTIPLEX AND RADIO THROUGH THE WIDE BAND PATCH BAY. MINIMUM INSTALLED ISOLATION OF THESE CABLES MEASURED FROM RADIO TO MULTIPLEX COMBING PANEL IN FREQUENCY RANGE OF 60KC TO
PAGE 2 RUFFECA1062 UNCLAS
3000KC IS 95DB WITH AVERAGE ISOLATION OF 110DB. RECEIVE LEVEL OF -15DBM AND TRANSMIT LEVEL -45DBM IS UTILIZED WITH NO DEGRADATION FROM CROSS TALK.
3. TYPICAL 3KC NOISE AND ISOLATION AVERAGE RESULTS OBTAINED BEFORE CUT TO NEW CABLE AND AFTER ARE PROVIDED BELOW FOR FOUR GROUPS IN SUPERGROUP 4, BETWEEN HILLINGDON AND MARTLESHAM HEATH:

BEFORE

	HIL	REC	MAM	REC
	3KC DBMO	X-TALK DB	3KC DBMO	X-TALK DB
4/1	57.3	54.4	60.4	55.6
4/2	60.7	58	62.5	58.4
4/3	60.6	58.6	59	58.6
4/4	61	57	59.4	56.4

AFTER

	HIL REG		MAM REC	
4/1	3KC DBMO	X-TALK DB	3KC DBMO	X-TALK DB
4/1	62.8	61.5	62.4	57.5
4/2	64.8	62	64.8	60

MESSAGE ROUTING INDICATOR

AGENCY	AC	CC	CS	CSS	DA	DE	DO	DP	EP	FF	HC	HO	IG	JA	LG	OA	OI	SG	XP	IGZ	CSB	DOOI	COMM CEN	DOCP DOCM	SUPVR NO.
ACTION									4																22
																									OPS NO.

4/3	64	62	64	57
4/4	65.4	61.5	65	58

3. SIMILAR IMPROVEMENTS IN ICN AND CROSS TALK WERE NOTED AT HILLINGDON NORTH TERMINALS, ALLCONBURY, WETHERSFIELD, MILDENHALL AND LAKENHEATH. NOISE PERFORMANCE ON THE HILLINGDON EAST SYSTEM IMPROVED AND AVERAGE OF 4DB IMMEDIATELY ON CHANGE OUT OF BASE BAND CABLES.

4. A REVIEW OF CURRENT LPAP DATA BEFORE AND AFTER THE 20 MAR 75 CABLE CHANGE OUT CLEARLY SHOWS THE MARKED IMPROVEMENT IN TASK 21 ENGLAND SYSTEM PERFORMANCE OBTAINED AND ILLUSTRATES THAT PROPERLY ENGINEERED AND INSTALLED 75 OHM TRIAX BASEBAND INTERFACES PROVIDE EXCELLENT RESULTS. CURRENT SUGGESTIONS TO USE PSEUDO-BALANCED CABLES WERE PREVIOUSLY CONSIDERED. RELATIVE ISOLATION TESTS WERE PERFORMED AT HILLINGDON USING BOTH TROMPETER TWINAX TWC-124-2 AND TROMPETER TRIAX TRC-75-2. RESULTS SHOWED TRIAX CABLE TO HAVE SLIGHTLY BETTER (10DB) ISOLATION THAN TWINAX (BALANCED). WHEN ADDITIONAL ISOLATION LOSSES ATTENDANT TO UTILIZATION OF IMPEDANCE MATCHING TRANSFORMERS WAS CONSIDERED, IT WAS EVIDENT THAT TRIAX CABLE WOULD YIELD BETTER ISOLATION FOR THE BASEBAND INTERFACES. THIS HAS PROVEN TRUE IN PRACTICE AS IS EVIDENCED BY THE IMPROVED CROSS TALK PERFORMANCE SHOWN IN PARA 3 ABOVE WHERE PSEUDO-BALANCED, TRANSFORMER COUPLED BASEBAND INTER-

FACES WERE REPLACED BY DIRECT CABLED TRIAX. CONVERSION OF BASEBAND CABLE INTERFACES FROM TRIAX CABLING TO PSEUDO-BALANCED CABLING WILL NOT YIELD BETTER SHSTEM PERFORMANCE. ON THE CONTRARY, SYSTEM DEGRADATION SHOULD BE EXPECTED ALONG WITH A REDUCTION IN RELIABILITY DUE TO THE NEED FOR ADDITIONAL TRANSFORMERS (4) AND CONNECTORS (8). MAINTENANCE RECORDS WILL VERIFY THAT CONNECTORS TEND TO BE THE MAJOR PROBLEM AREA ASSOCIATED WITH BASEBAND CABLES AFTER INSTALLATION. TRANSFORMERS PROVIDED TO THE AIR FORCE WITH KAR KAR BASEBAND AMPLIFIERS HAVE FAILED ON SEVERAL OCCASIONS TO DATE DURING USE IN BASE-BAND CABLE PLANTS. AN INSPECTION MADE AT RHEIN MAIN OF A PSEUDO-BALANCED FIX REVEALED THAT THE FIX SERVED ONLY TO BREAK A GROUND LOOP CONDITION WHICH EXISTED AS A RESULT OF A MINOR INSTALLATION ERROR.

5. A NEED FOR BASEBAND CABLE ANALYSIS AND CORRECTIONS EXISTS AT ALL AIR FORCE SITES WHERE AUGSBURG UPGRADE EQUIPMENTS ARE INSTALLED. THIS PROBLEM HAS BEEN DISCUSSED WITH DCA EUR WITH THE AIM OF CREATING A DCA SPONSORED TEAM TO CORRECT BASEBAND PROBLEMS AT AUGSBURG SITES AS WELL AS AUGSBURG IMPACTED SCOPE COMM SITES. IT IS IMPERATIVE TH

T SUCH A TEAM BE TRAINED IN
PAGE 5 RUFFECA1062 UNCLAS
ANALYSIS, TEST, INSTALLATION AND CUT OVER TECHNIQUES AS DEVELOPED FOR THE HILLINGDON NORTH SYSTEM. MR. LADIEU, ECA/EPZ (ENGINEER) AND MR. STOECKLE, ECA/EPZ (TECHNICIAN), PERSONNEL WHO HAVE BEEN CONTINUUOUSLY INVOLVED IN THE HILLINGDON NORTH UPGRADE, ARE CURRENTLY TASKED WITH SCHEME PREPARATION FOR SCOPE COMM CLEANUP. CURRENT SCHEDULES WILL NOT PERMIT THEIR PARTICIPATION IN THIS BASEBAND CORRECTION EFFORT.
6. INSPECTION OF AUGSBURG RADIO/MUX INTERFACES AT FELDBERG AND LANGERKOPF SHOW BASEBAND INSTALLATION ERRORS TO BE CLEARLY EVIDENT. IMPROPER BASEBAND INSTALLATION ON THE AUGSBURG EQUIPMENTS RESULTS IN NOISE AND CROSS TALK DEGRADATION OF CO-LOCATED SCOPE COMM EQUIPMENTS. A CONSERVATIVE ESTIMATE OF NOISE REDUCTION AT LANGERKOPF THROUGH CORRECTION OF AUGSBURG BASE BANDS IS 4DB AVERAGE. SUCH CORRECTIVE ACTION WOULD REQUIRE FULL COORDINATION AND SUPPORT FROM ASSOCIATED ARMY TERMINALS IN ORDER TO DEVELOP BASELINE DATA BEFORE AND AFTER CUTOVERS. IT IS ESSENTIAL TH
T
ANY SYSTEM DEGRADATIONS OCCURRING DURING BASE BAND CHANGE OUTS BE IMMEDIATELY ANALYZED AND THE CAUSE IDENTIFIED EITHER AS BASE BAND OR EQUIPMENT CONNECTED. EXPERIENCE HAS SHOWN THAT EQUIPMENT DEGRADATION TALKING PLACE SIMULATANEOUSLY WITH BASEBAND
PAGE 6 RUFFECA1062 UNCLAS
REPLACEMENTS IS GENERALLY CONSIDERED AS BASEBAND FAULTS UNTIL PROVED OTHERWISE.
7. THE FOREGOING INFORMATION IS PROVIDED IAW REFERENCED DISCUSSION. FURTHER INFORMATION IN REPORT FORM MUST BE HELD IN ABEYANCE PENDING COMPLETION OF SCOPE COMM SCHEME EFFORT.
BT
#1062
NNNN
R 0981947 ACK

ROUTINE 313

RTTUZYUW RUDOECA3512 2971543-UUUU--RUKTAAA.
ZNR UUUUU
R 241400Z OCT 75
FM ECA LINDSEY AS GE/EP
TO RUKTAAA/AFCS RICHARDS GEBAUR AFB MO/EPEU/DDYM/LGMSR—
INFO RUEDBJA/NCA GRIFFISS AFB NY/EPE
ZEN/ECA LINDSEY AS GE/LGM/LGMHS
RHFRAAB/DET 25 1945CG LANGERKOPF GE/LGM
BT
UNCLAS
SUBJ: LANGERKOPF GROUND AND NOISE PROBLEMS
REF: A. OUR 111420Z AUG 75 (NOTAL)
B. YOUR 201815Z OCT 75 (NOTAL)

1. PRIOR TO THE COMPLETE CLOSE OUT OF THE SCOPE COMMOFFICE IN EUROPE THIS SEPTEMBER, MR.LA DIEU COMPLETED A FULL REPORT OF FINDINGS AND RECOMMENDED BASEBAND CABLE ENGINEERING PRACTICES. A COPY OF THAT REPORT WAS RECENTLY SENT TO HQ AFCS/EPEC/LGMSR/DDYM.

2. MR. STOECKLE, FORMERLY ATTACHED TO ECA/EPZ, SCOPE COMM, HAS TRANSFERRED TO LANGERKOPF. HE HAS CONTINUED TO PURSUE AN INVESTIGATION INTO THE NOSIE PROBLEMS SUPSECTED TO BE WITHIN THE CABLE PLANT AT LANGERKOPF. MR. STOECKLE AND PERSONNEL FROM BOTH THE 1945CG AND DET 25 RECENTLY IDENTIFIED ANOPEN IN THE OUTER SHIELD OF

ONE OF THE TRANSMIT BASEBAND CABLES ON THE LINK TO VAIHINGEN THRU FRIOLZHEIM AND STUTTGART. REPAIRING THE OUTER SHIELD CONNECTION REDCES THE IDLE CHANNEL NOISE SEEN IN 4 GROUPS AT VAIHINGEN SIGNIFICANTLY. PMP DATA SHOWS A CONSTANT ICN READING IN THE LOWER 50'S PRIOR TO CABLE REPAIR. AFTER CABLE REPAIR ICN READINGS ARE APPROXIMATELY -61 DBMO. THIS IMPROVEMENT ILL BE CLOSELY MONITORED BY ECA/EPE TO CONFIRM CABLE REAPIR HAS DEFINITELY IMPROVED SYSTEM PERFORMANCE. MR. STOECKLE AND OTHER MAINTENANCE PERSONNEL ARE PRESENTLY DIRECTING THEIR EFFORTS TOWARD THE LANGERKOPF-MUEHL LINK.

3. WITH DELETION OF THE SCOPE COMM OFFICE, ENGINEERING RESPONSIBLITY WAS TRANSFERRED TO NCA/EPE PER AFCS PAD 21-75, 3 JUL 75. IN DEALING WITH BASEBAND CABLE AND CABLE GROUNDING PROBLEMS PAST EXPERIENCED INDICATES THAT POSITIVE RESOLUTION OF PROBLEM AREAS CANNOT BE EFFECTIVELY HANDLED BY SHORT TERM TDY PERSONNEL. THE LEARNING AND EXPERIENCE FACTOR ON BASEBAND CABLE PLANTS IS EXTREMELY IMPORTANT. ECA/EP IS PRESENTLY WORKING ON A PROPOSAL WHICH WE WILL FORWARD TO HQ AFCS AND NCA. THE BASIC RECOMMENDATION WILL BE TO FORM A SMALL TEAM (NOT UNLIKE A SCOPE CREEK TEAM) THAT WILL BE DEDICATED FOR A

MESSAGE ROUTING INDICATOR

AGENCY	AC	CC	CS	CSS	DA	DE	DO	DP	EP	FF	HC	HO	IG	JA	LG	OA	OI	SG	XP	IGZ	CSB	DOO:	COMM CEN	DOCP DOCM	SUPVR NO.
ACTION																									
INFO																									OPS NO.

AFCS HQ FORM 0-48, AUG 74 PREVIOUS EDITIONS WILL BE USED.

PERIOD OF TIME TO INVESTIGATING AND CORRECTING BASEBAND CABLE DEFICIENCIES. I EXPECT THAT SUCH A PROGRAM WOULD BE COST EFFECTIVE
PAGE 3 RUDOECA3512 UNCLAS
AND COULD EASILY BE USED ON NON-SCOPE COMM INSTALLATIONS WITHIN THE DCS. EXPERIENCED PERSONNEL IN THIS AREA LIKE MR. LA DIEU OR MR. STOECKLE COULD BE INVOLVED SO AS NOT TO LOSE THEIR EXPERTISE AND SHORTEN TEAM TRAINING TIME.
4. THE AC POWER GROUNDING PROBLEM REMAINS A FIRM TASKING TO THE 1836EIS PER PARA 2 OF REF A. AT PRESENT, AUGMENTATION IS DELAYED BECAUSE OF HIGHER PRIORITY WORKLOAD.
BT
#3512
NNNN
R 2972053 ACK

01 05 RR RR UUUU 081520 Z AUG 75

NO

ECA LINDSEY AS/EPE

AFCS RICHARDS GEBAUR AFB MO/EPE/EPECR

INFO: DET 12 1945 COMM GP FELDBERG GE

DCA EUR VAIHINGEN GE/E425

UNCLAS

SUBJ: TEST OF BASEBAND CABLE INTERFACE FOR FELDBERG-LANGERKOPF

REF: AFCS/EPE 161450Z JUL 75

1. TESTING OF SIEMEN'S BASEBAND CABLE INTERFACE COMPONENTS IAW REF MSG WAS ACCOMPLISHED 4 AUG 75 ON THE FELDBERG-LANGERKOPF SYSTEM. DUE TO LACK OF INSTALLED CABLING FOR SIEMEN'S ATTENUATOR IN SIEMEN'S MUX BAY AT LANGERKOPF, IT WAS NECESSARY TO PROVIDE PADDING FOR TRANSMIT WITH IN-LINE SHIELDED STEP ATTENUATOR INSTALLED AT RADIO TERM FILTER. INTERFACE CONFIGURATION AT FELDBERG WAS INSTALLED AS ORIGINALLY INTENDED: OUTPUT OF MUX TRANSMIT PASSED THROUGH BAY CABLING TO SIEMEN'S ATTENUATOR THEN THROUGH SIEMENS'S 150/75 OHM MATCHING TRANSFORMER TO BASEBAND CABLE.

2. TEST SEQUENCE WAS AS FOLLOWS:

TELE. COORD. LGHS CMS WISEMAN
8 Aug 75

8 Aug 75

Coord: EPE
Capt Cohen 8 Aug 75

8 Aug

F. LA DIEU, GS-12, EPE, 23403

IAN FELTHAM, GS-13, EPE, 24270

FILE COPY

02 05 RR RR UUUU

NO Z AUG 75

A. BALANCED CABLE WITH TRANSFORMER INTERFACE AT BOTH FELDBERG AND LANGERKOPF.

B. UNBALANCED CABLE WITH: ORIGINAL SIEMEN'S COMPONENT CONFIGURATION AT FELDBERG; SIEMEN'S TRANSFORMER WITH EXTERNAL ATTENUATION AT LANGERKOPF.

C. UNBALANCED CABLE WITH EXTERNAL TRANSMIT PADDING AND SIEMEN'S TRANSFORMERS AT BOTH FELDBERG AND LANGERKOPF.

3. DATA FOR CROSS TALK, 3 KC FLAT AND C MSG NOISE WAS RECORDED FOR ALL CHANNELS AND AVERAGED FOR EACH TEST. RESULTS WERE AS FOLLOWS:

FELDBERG RECEIVE (EVALUATES LANGERKOPF INTERFACE PERFORMANCE):

	X-TALK	3KC	C MSG
SEQUENCE A.	62.36	62.75	65.30
B.	62.15	62.70	65.00

F. LADIEU, GS-12, EPE, 23403

IAN FELTHAM, GS-13, EPE, 24270

LANGERKOPF RECEIVE (EVALUATES FELDBERG INTERFACE PERFORMANCE).

A.	59.50	59.80	61.93
B.	54.44	57.48	59.26
C.	59.95	60.70	63.08

4. CONCLUSIONS: LANGERKOPF RECEIVE DATA SEQUENCE B SHOWS CROSS TALK TAKING PLACE IN SIEMENS PAD, AT FELDBERG. SEQUENCE B DATA TAKEN AT FELDBERG SHOWS NO SIGNIFICANT DIFFERENCE IN UNBALANCED VERSUS BALANCED CABLE PERFORMANCE AT LANGERKOPF. THE SAME EQUIVALENCY OF PERFORMANCE IS SEEN AT FELDBERG WHEN SEQUENCE A AND C FOR LANGERKOPF RECEIVE IS COMPARED. DATA DEMONSTRATES THAT THE EQUIPMENT INTERFACE COMPONENTS RATHER THAN TYPE OF CABLE UTILIZED (BALANCED OR UNBALANCED) ARE DETERMINING THE PERFORMANCE OF THE BASEBAND CABLE PLANT. SIEMENS FU60/120 MULTIPLEX EQUIPMENT IS DESIGNED TO OPERATE EQI-LEVEL TRANSMIT/RECEIVE AT BASE BAND FREQUENCIES. ATTEMPTS TO OPERATE

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THIS EQUIPMENT AT -15/-45 DBM LEVELS INTERNALLY IN MUX RACKS DEMANDS 30 DB MORE ISOLATION THAN NORMALLY REQUIRED OF BASEBAND INTERFACE COMPONENTS. DATA SHOWS MUX TO FALL BETWEEN 5 TO 8 DB SHORT OF MEETING THIS OBJECTIVE.

5. RECOMMENDATIONS: THE DATA SHOWS THAT THE RELOCATION OF THE 150/75 OHM INTERFACE TRANSFORMERS HAS ACHIEVED ADEQUATE ISOLATION BETWEEN THEM. THE REMAINING PROBLEM IS IN THE SIEMENS TRANSMIT ATTENUATOR. THIS CAN BE OVERCOME BY PROVIDING AN IN-LINE TRIAX ATTENUATOR FOR INSTALLATION DIRECTLY IN THE REAR OF THE WIDEBAND PATCH FIELD. THE ATTENUATOR CAN BE CONNECTED TO THE EXISTING PARALLEL NETWORK ON THE BASEBAND TRANSMIT MODULES. THE EXISTING TRIAX TRANSMIT CABLE CAN CONNECT DIRECTLY TO THE ATTENUATOR. AT THE MUX, THE SIEMENS'S PAD CAN BE BYPASSED MAKING POSSIBLE INTERNAL EQI-LEVEL OPERATION OF THE TRANSMIT/RECEIVE PORTION OF SIEMENS MUX. TRANSMIT/RECEIVE LEVELS WILL BE CARRIED AT A -15 DBM LEVELS FROM MUX TO WIDEBAND PATCH WHERE

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05 05 RR RR UUUU Z AUG 75

NO

TRIAX IN LINE PAD WILL PROVIDE -45 DBM LEVEL FOR WIDEBAND PATCH APPEARANCE AND TRANSMIT TO RADIO. ORIGINAL BASEBAND CABLING INSTALLATION WILL BE UTILIZED AS INSTALLED. RECOMMENDED IN LINE ATTENUATOR IS THE TROMPETER TNG-75-28 DB-TRIAX MALE TO FEMALE.

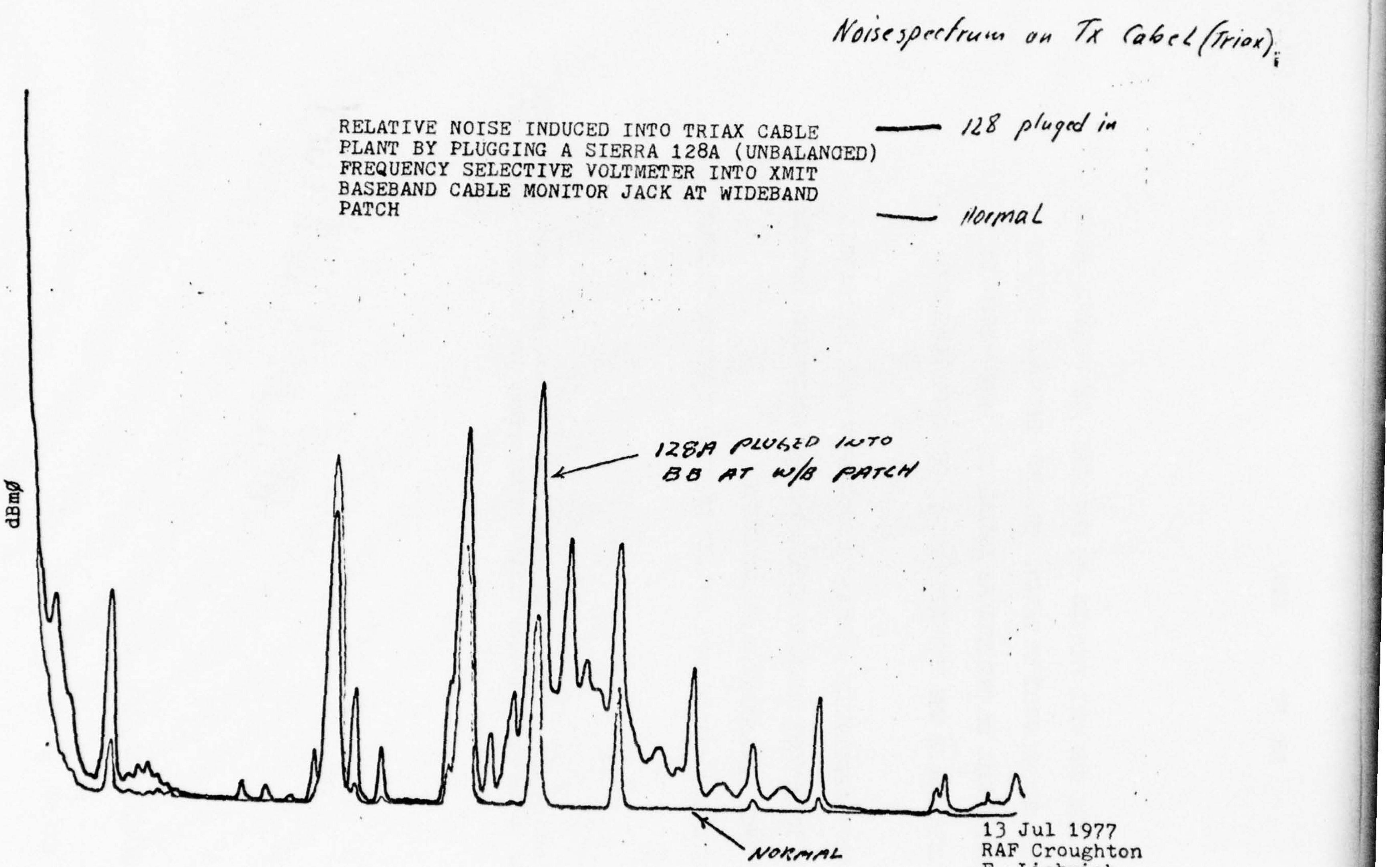
6. ON YOUR CONCURRENCE WITH ABOVE RECOMMENDATION, ACTION WILL BE TAKEN TO PROCURE REQUIRED ATTENUATOR AND ACCOMPLISH INSTALLATION THEREOF AT LANGERKOPF AND FELDBERG.

7. TEST DATA CITED IN PARA 4 ABOVE IS BEING FORWARDED TO EPECR BY MAIL.

MFR: Testing and evaluation cited in this ~~TWX~~ msg was requested by AFCS/EPE in order to determine proper radio/mux interface for Feldberg-Langerkopf link.

P. LA DIEU, GS-12, EPE, 23403

IAN FELTHAM, GS-13, EPE, 24270



13 Jul 1977
RAF Croughton
F. Liebrich
W. Stoeckle

Figure 200.42

FREQUENCY SIGNATURE FOR TRIAX CABLE PLANT
AT RAF CROUGHTON BEFORE CORRECTION OF DEFECTS

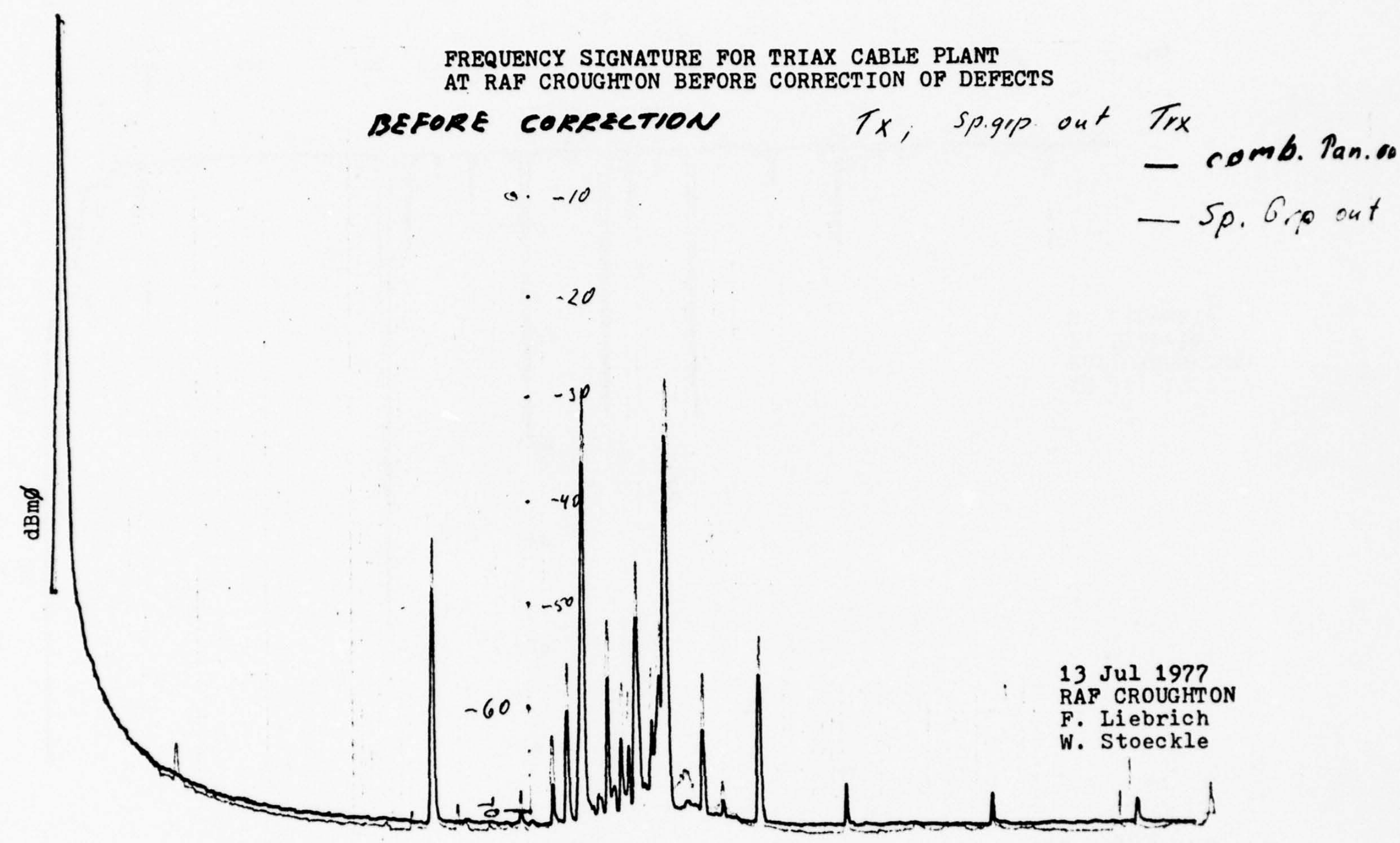


Figure 200.43

COMPARATIVE DATA FOR TRIAX (UNBALANCED) AND TWINAX (BALANCED)
CABLE PLANTS AT RAF CROUGHTON, U.K. FOLLOWING CORRECTION OF CABLE PLANT DEFECTS

AFTER CORRECTION

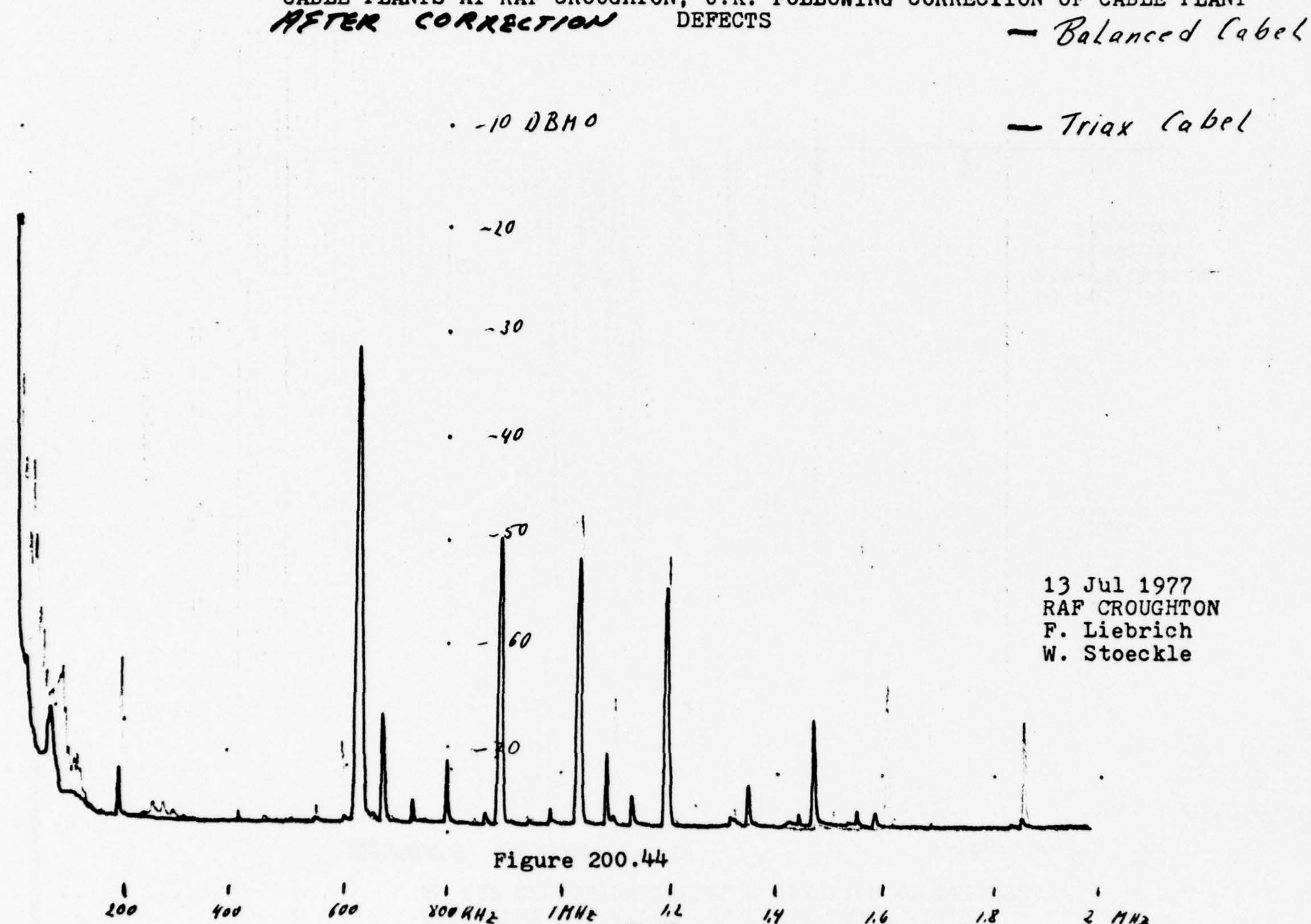


Figure 200.44

13 Jul 1977
RAF CROUGHTON
F. Liebrich
W. Stoeckle

RFI X-Y DATA PLOT TRACE FOR BALANCED
BASEBAND CABLE PLANT-RAF CROUGHTON

SIGNATURE FOR
TWINAX (BALANCED) CABLE PLANT AT RAF CROUGHTON
AFTER CORRECTION OF DEFECTS
(Traced from Figure 200.44)

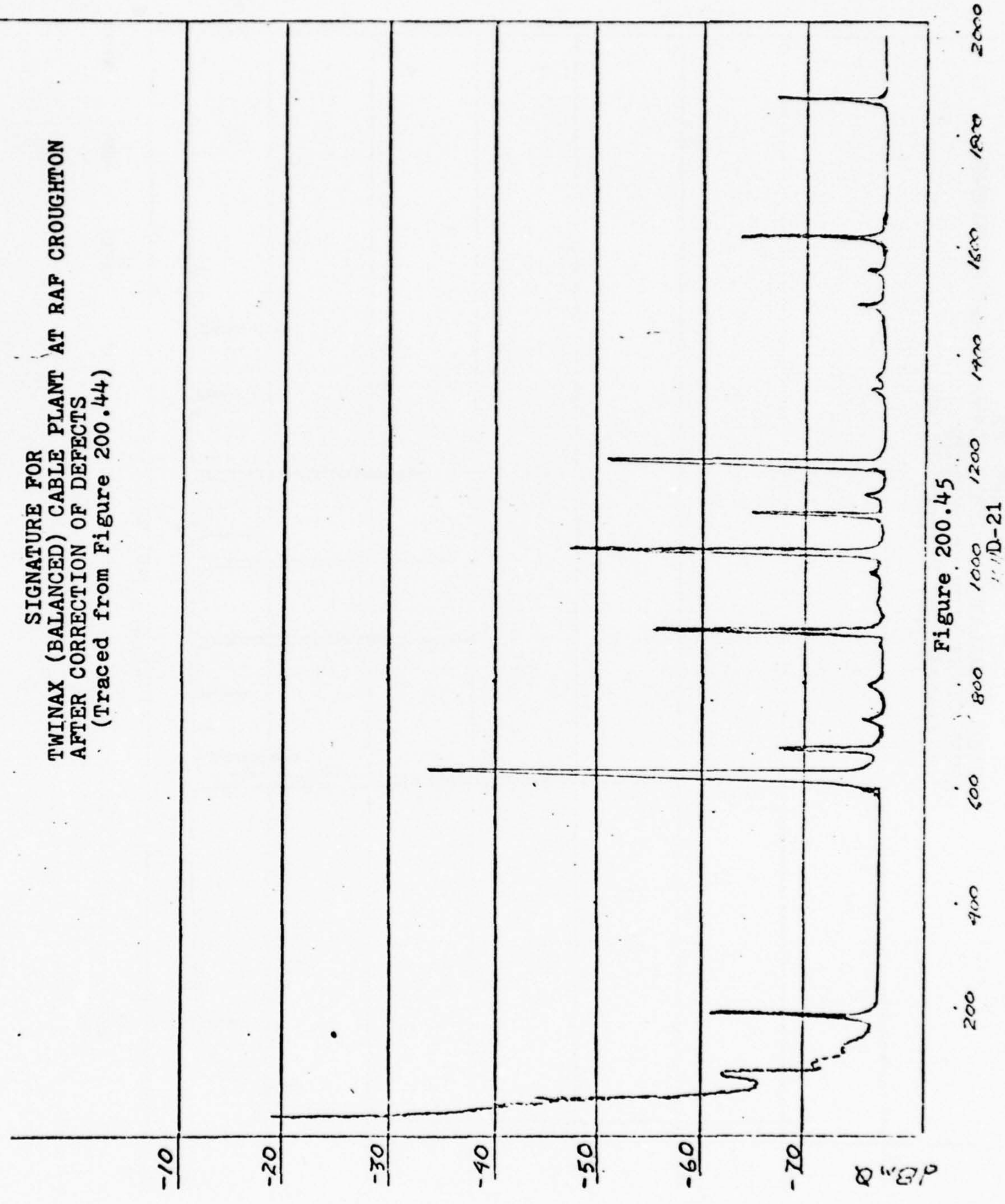
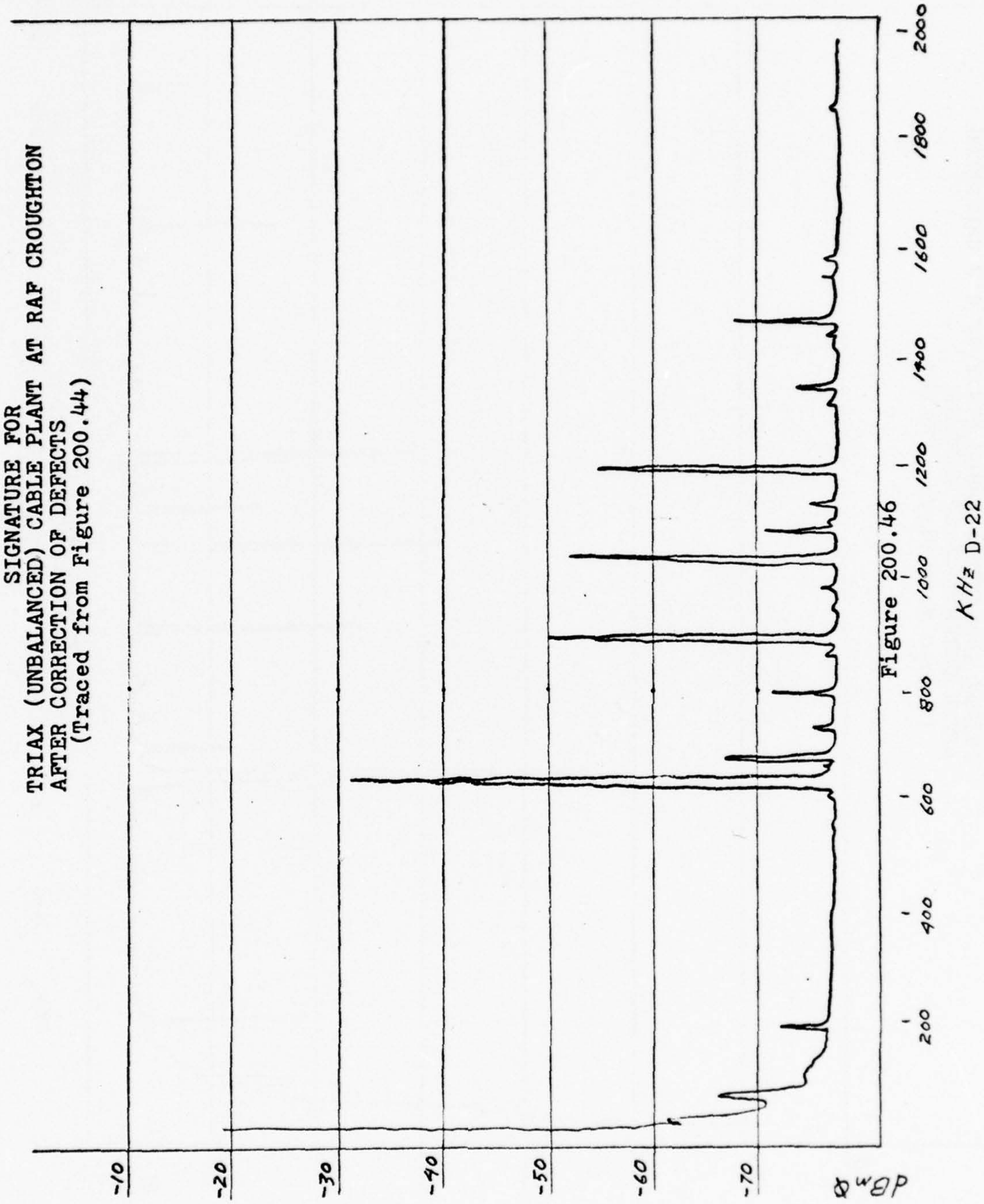


Figure 200.45

RFI X-Y DATA PLOT TRACE FOR UNBALANCED
BASEBAND CABLE PLANT - RAF CROUGHTON



SIGNATURE FOR
TRIAX (UNBALANCED) CABLE PLANT AT RAF CROUGHTON
AFTER CORRECTION OF DEFECTS
(Traced from Figure 200.44)

Figure 200.46

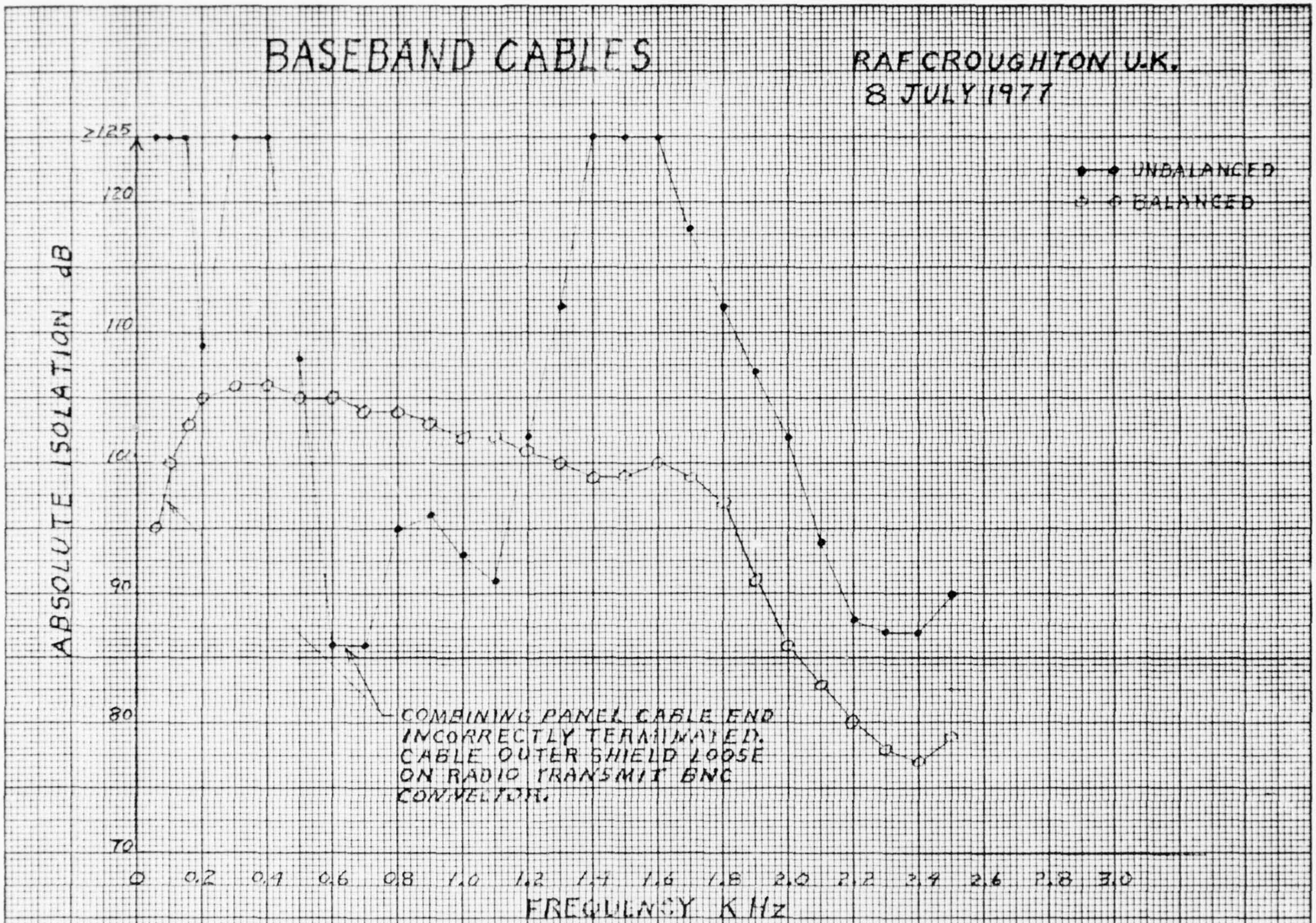


Figure 200.47

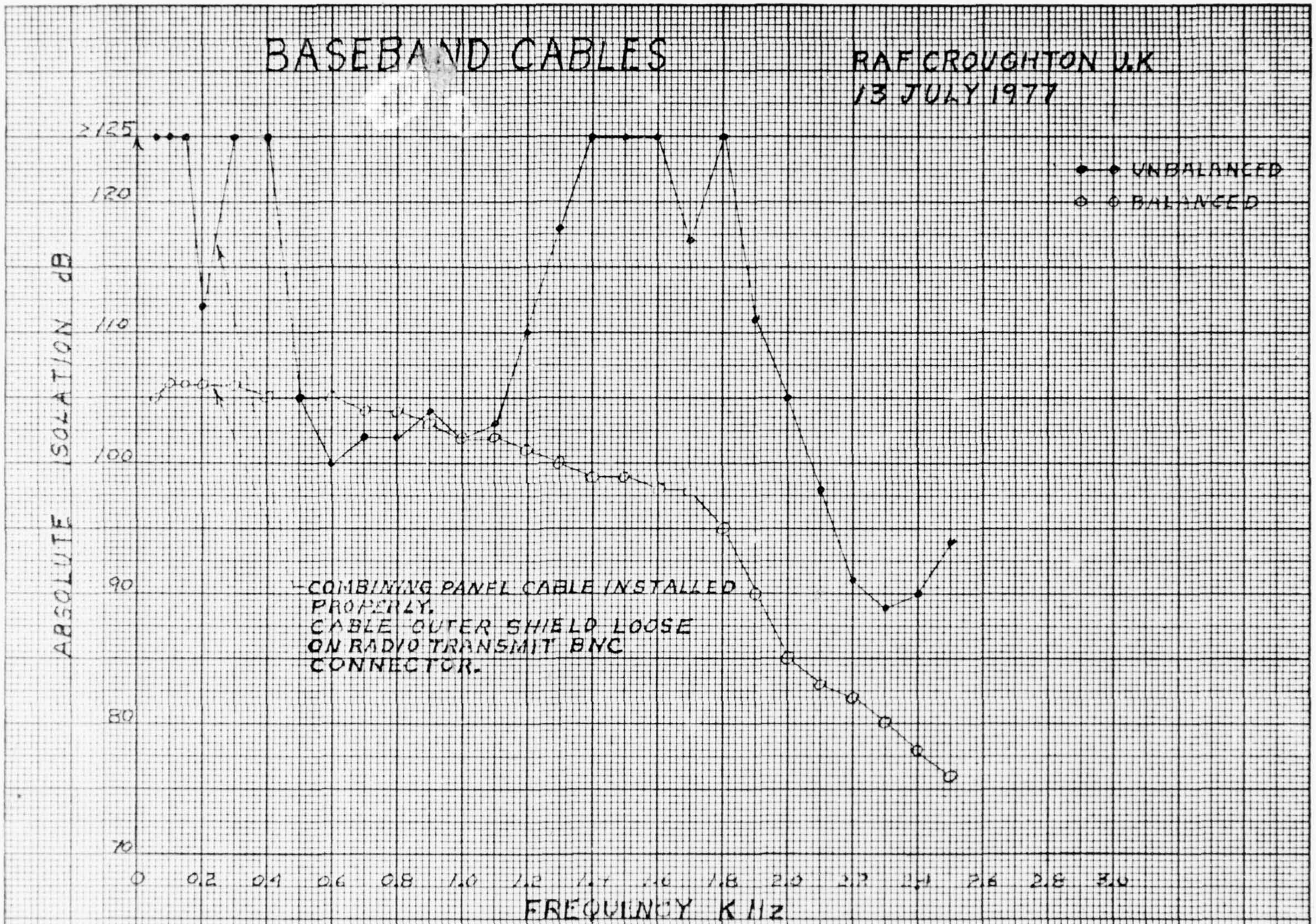


Figure 200.48

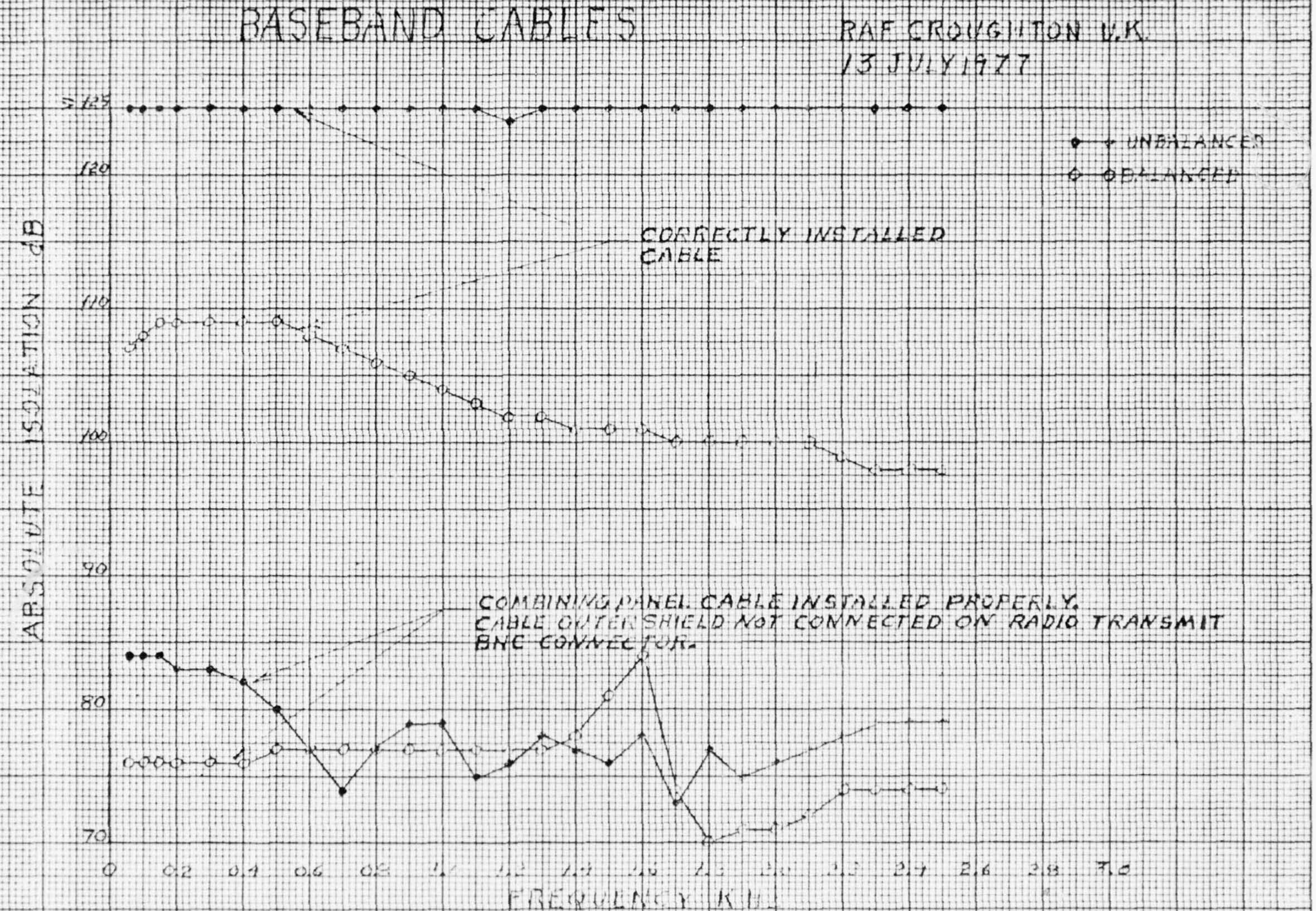


Figure 200.49

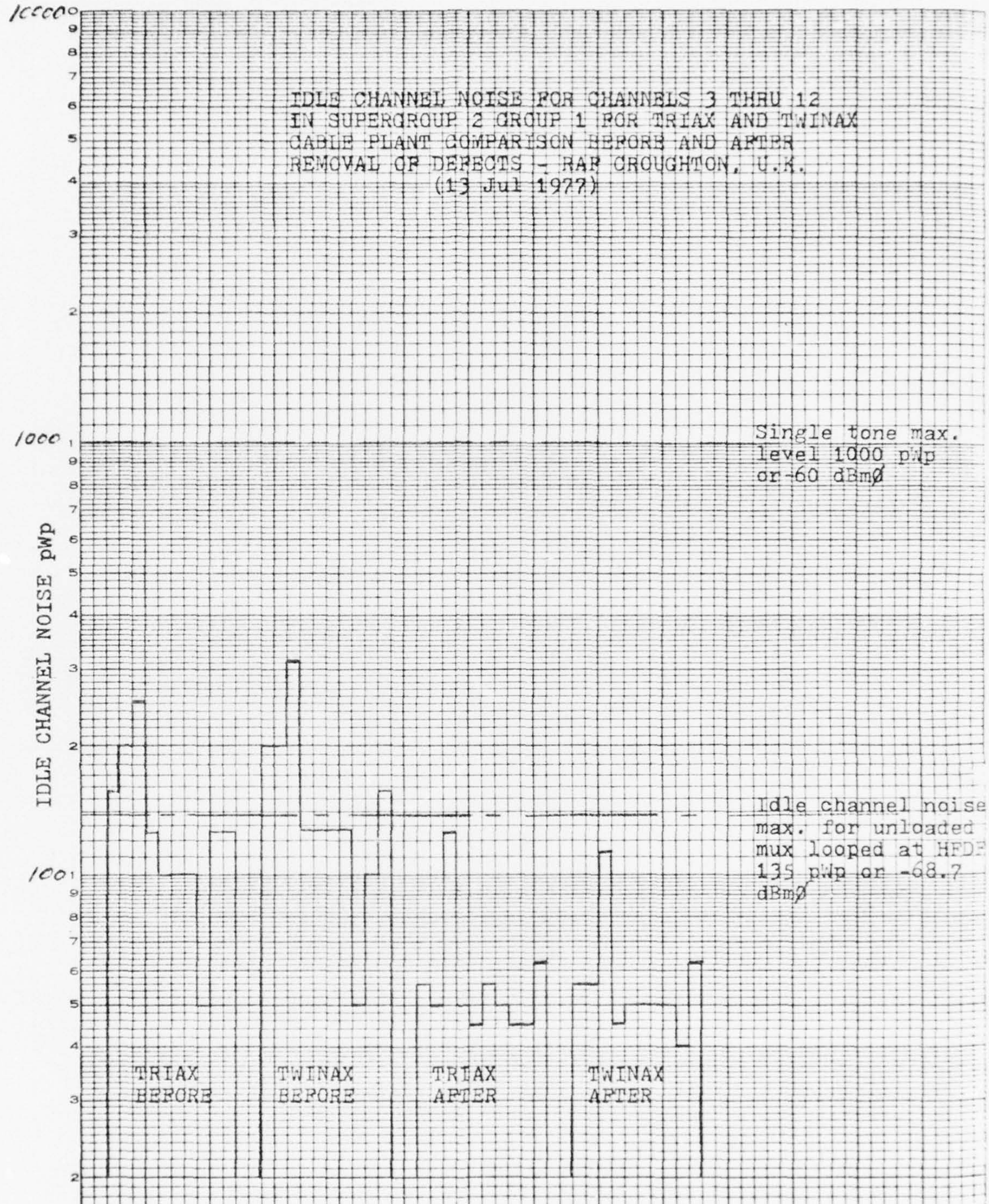


Figure 200.50

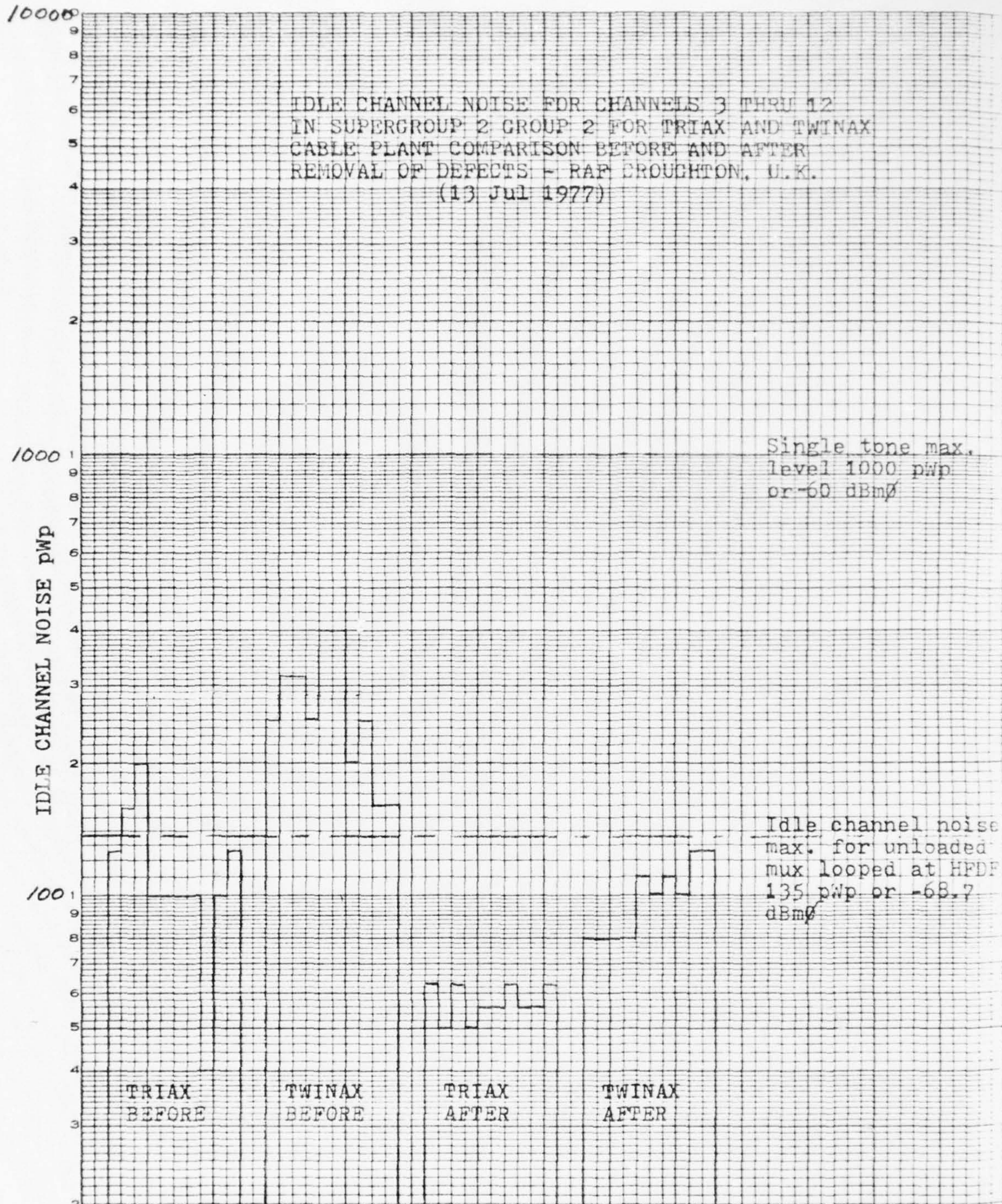


Figure 200.51

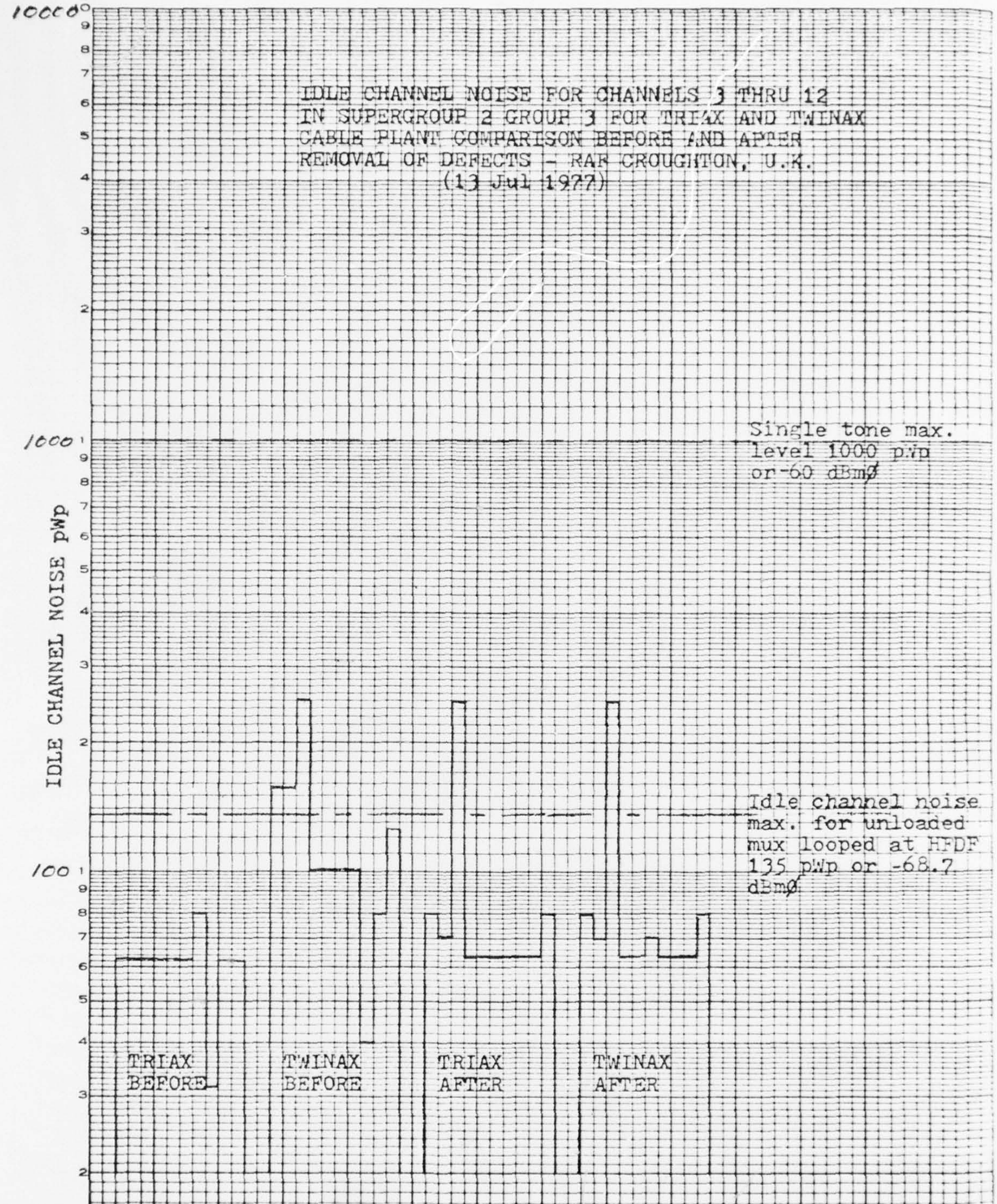
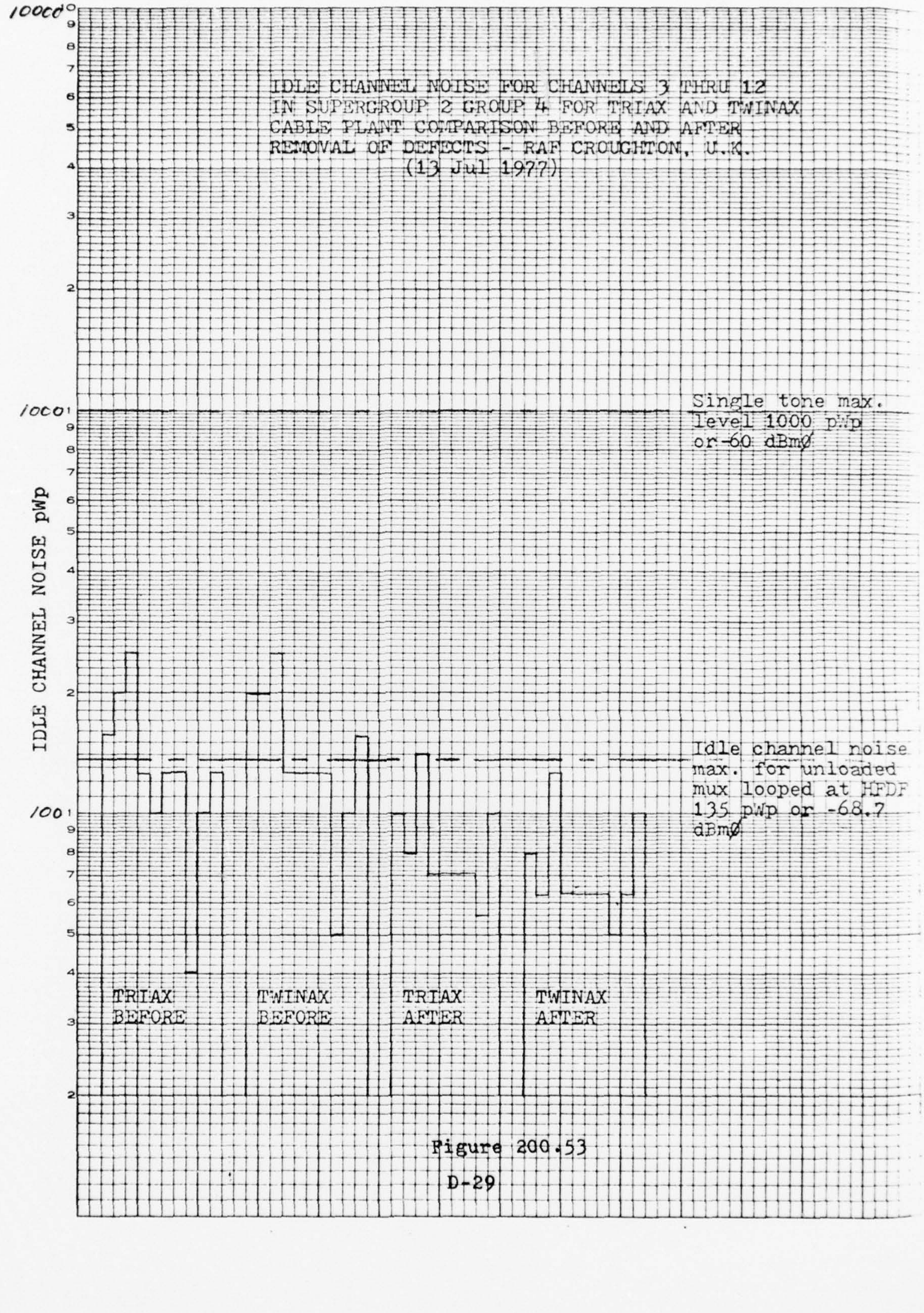


Figure 200.52



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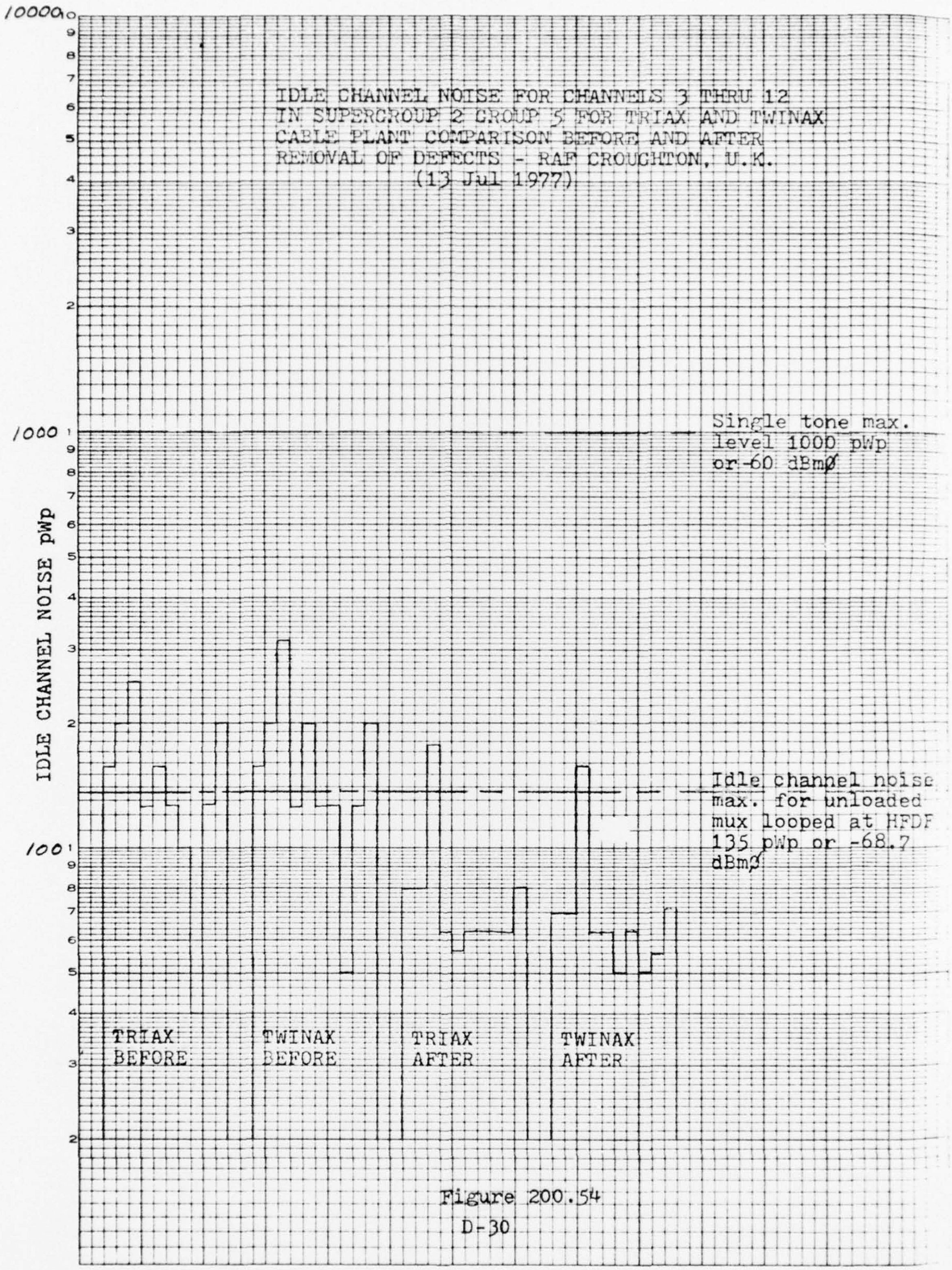

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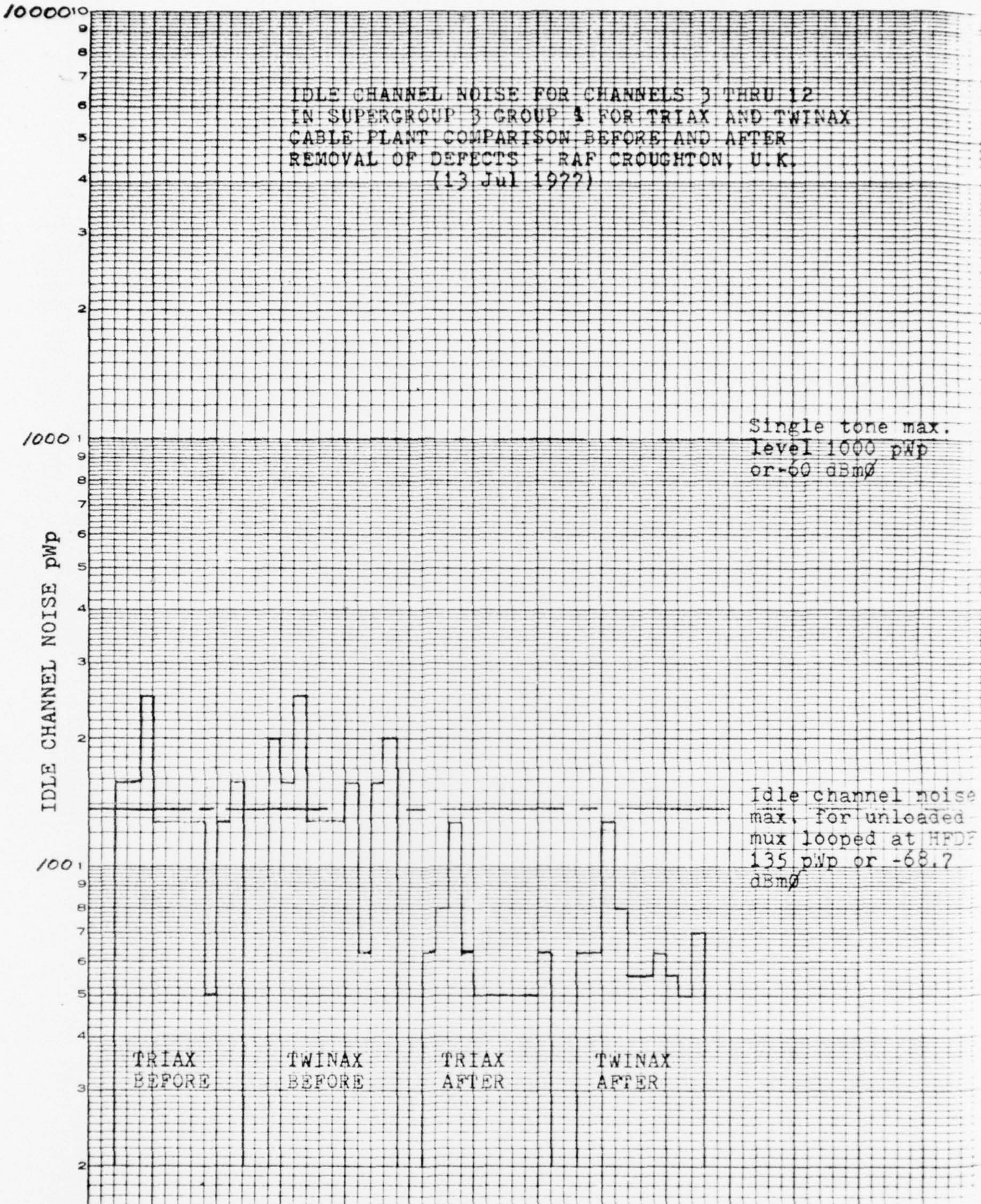

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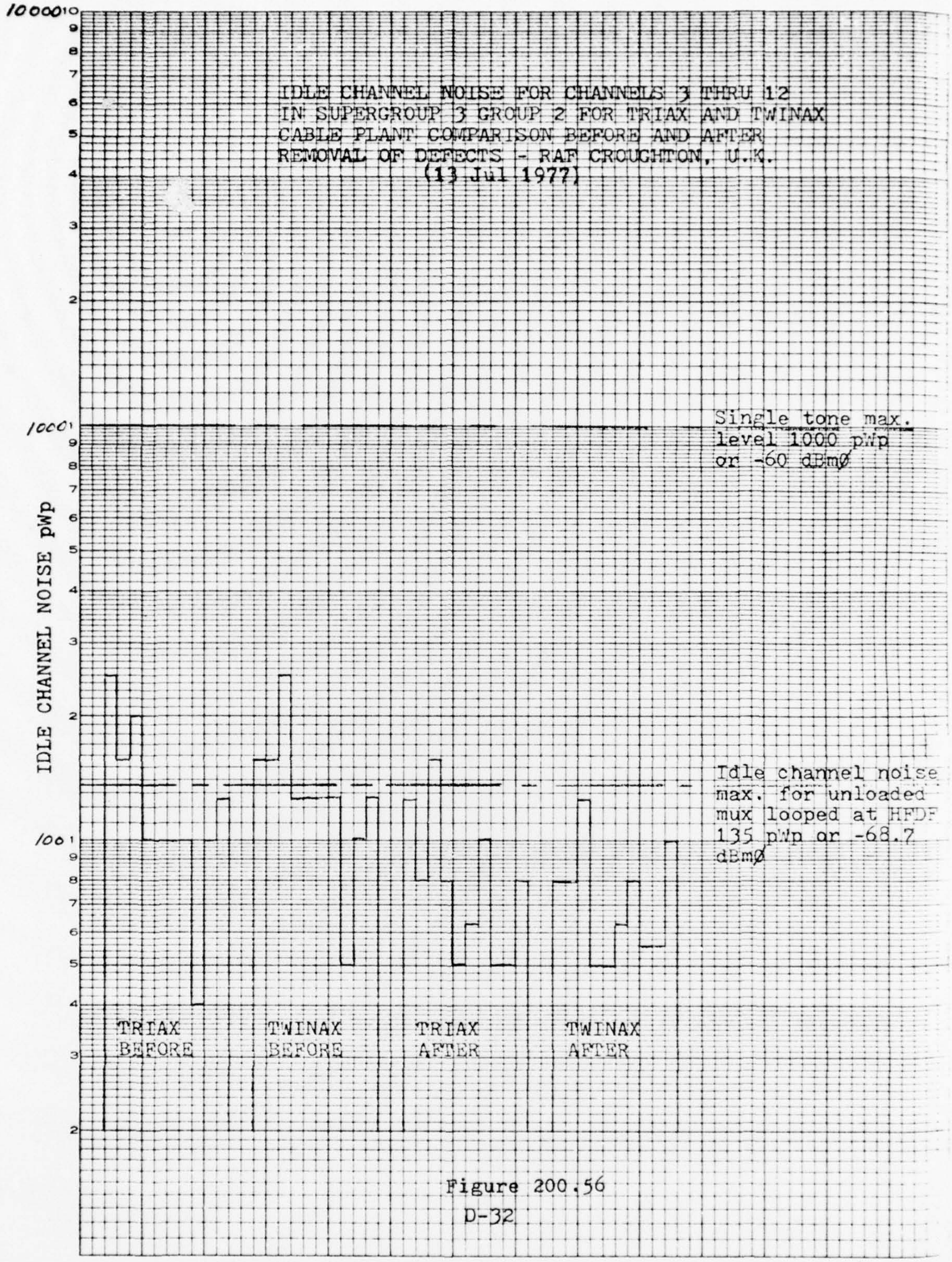

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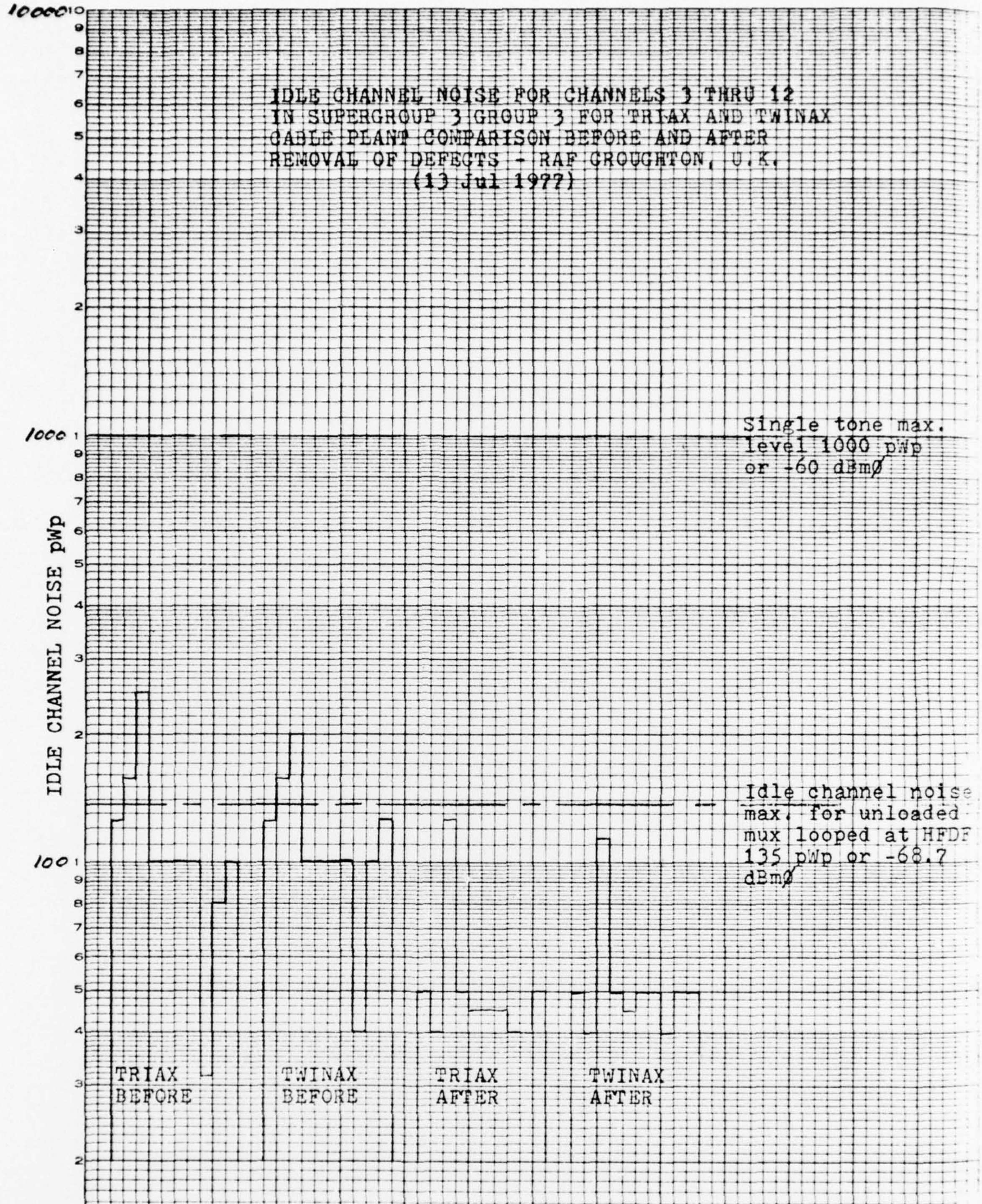

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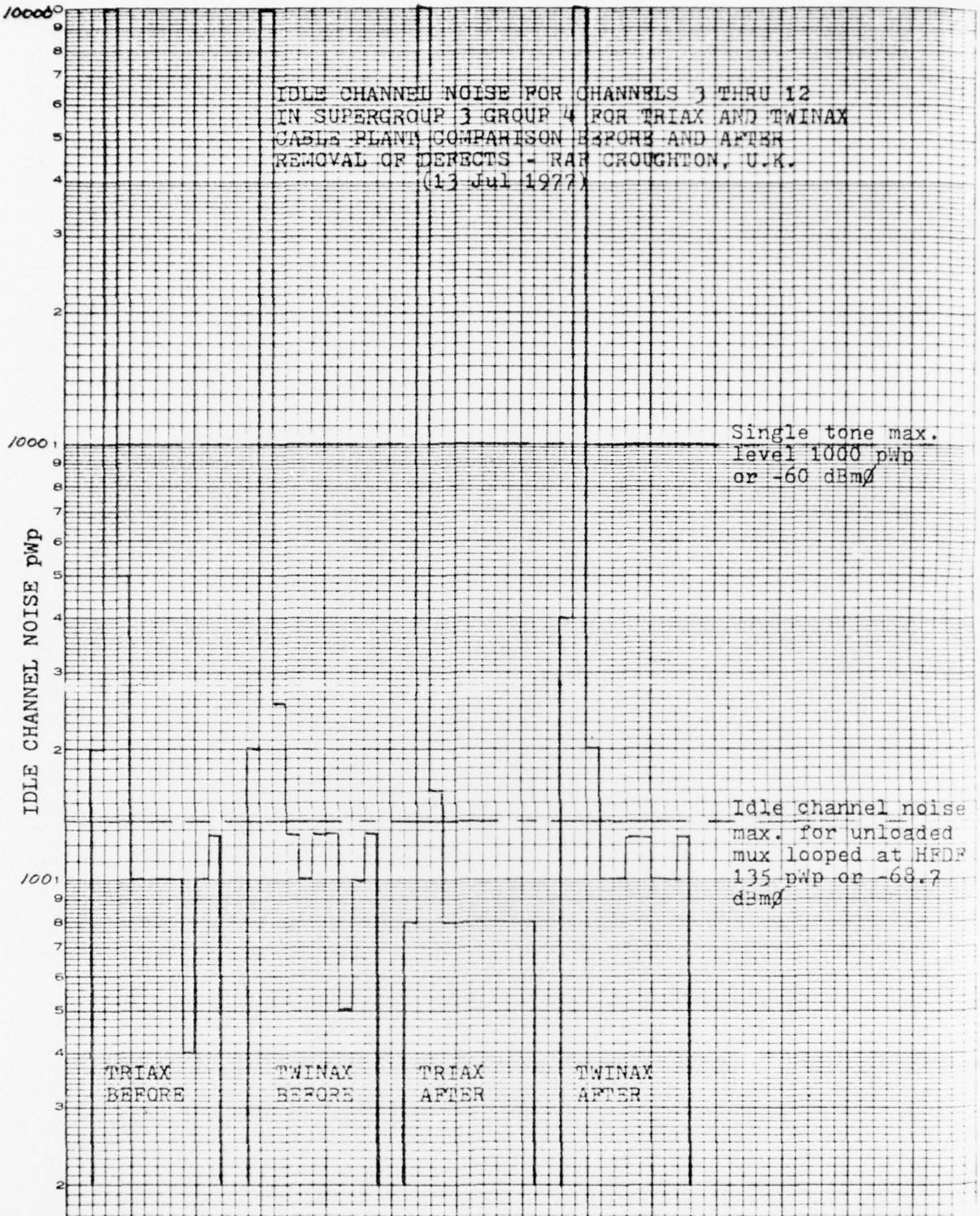

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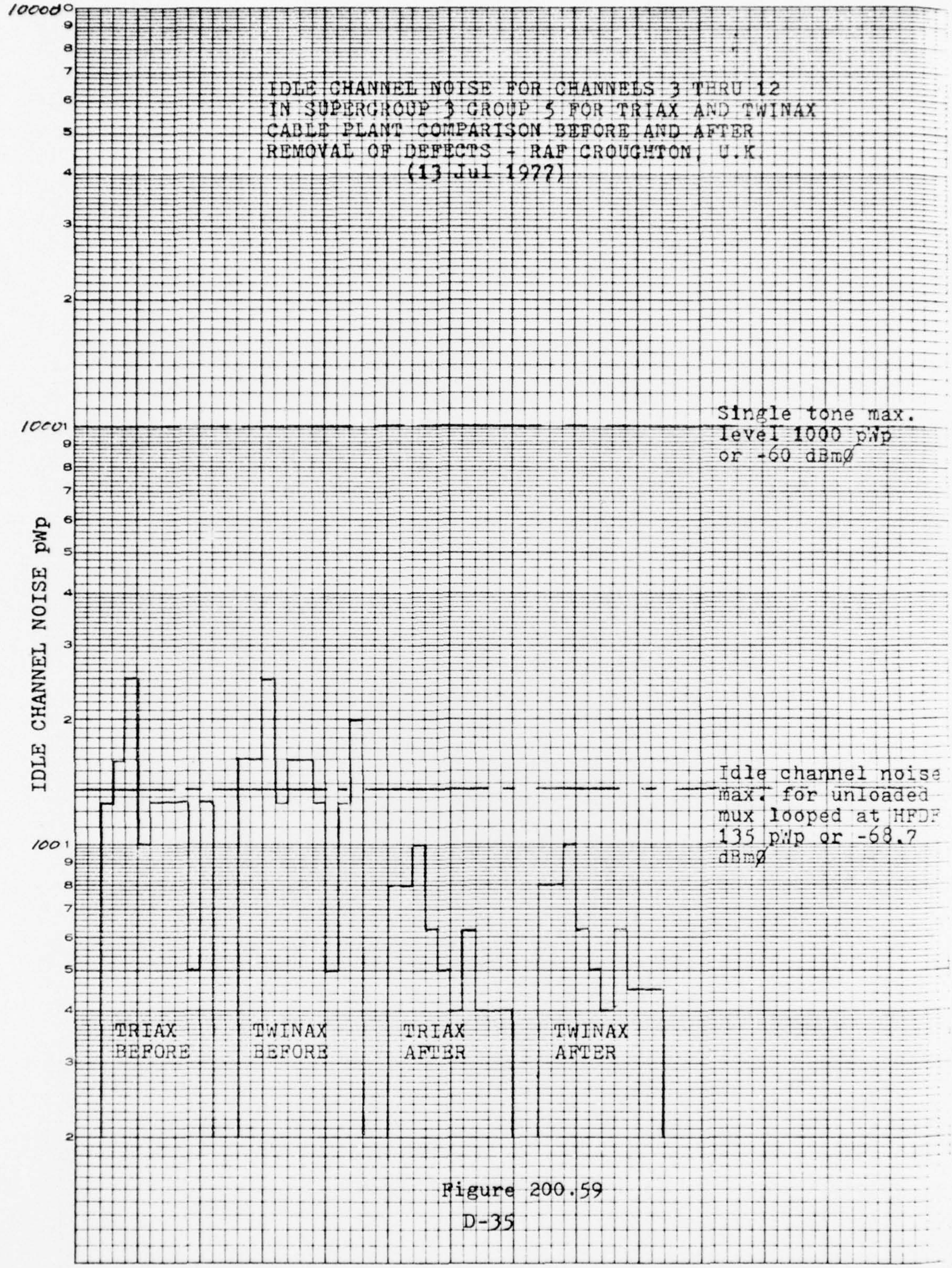

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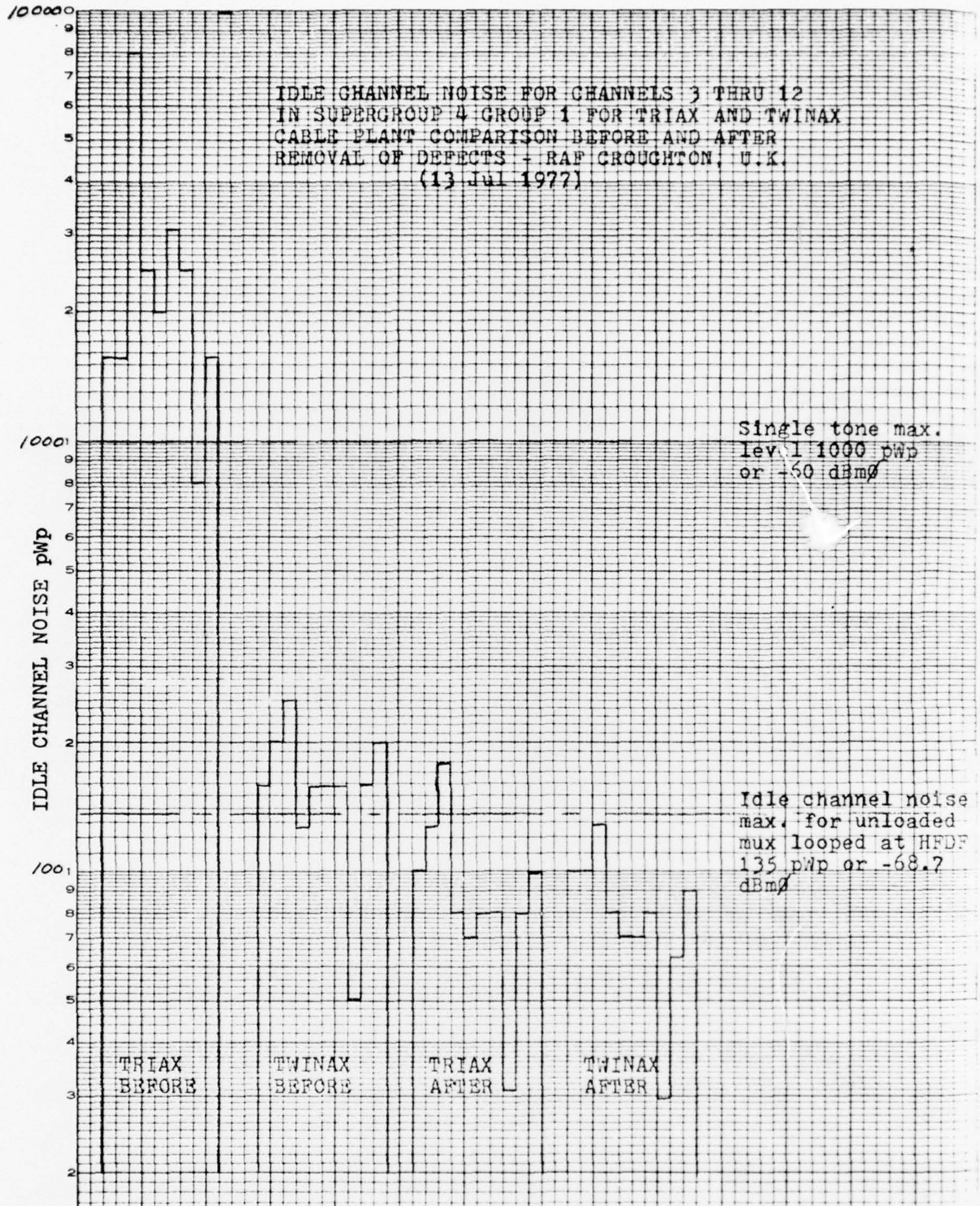

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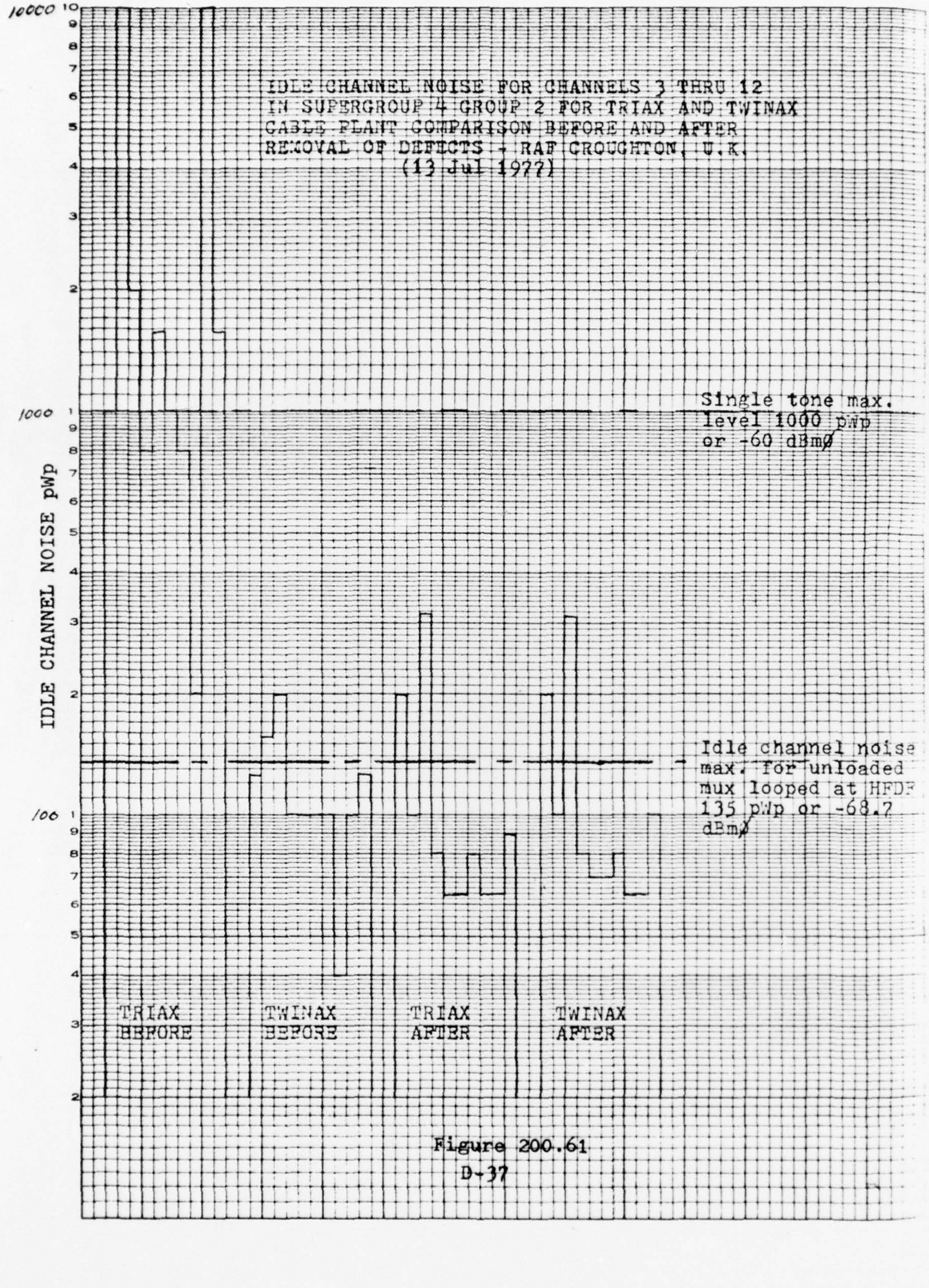

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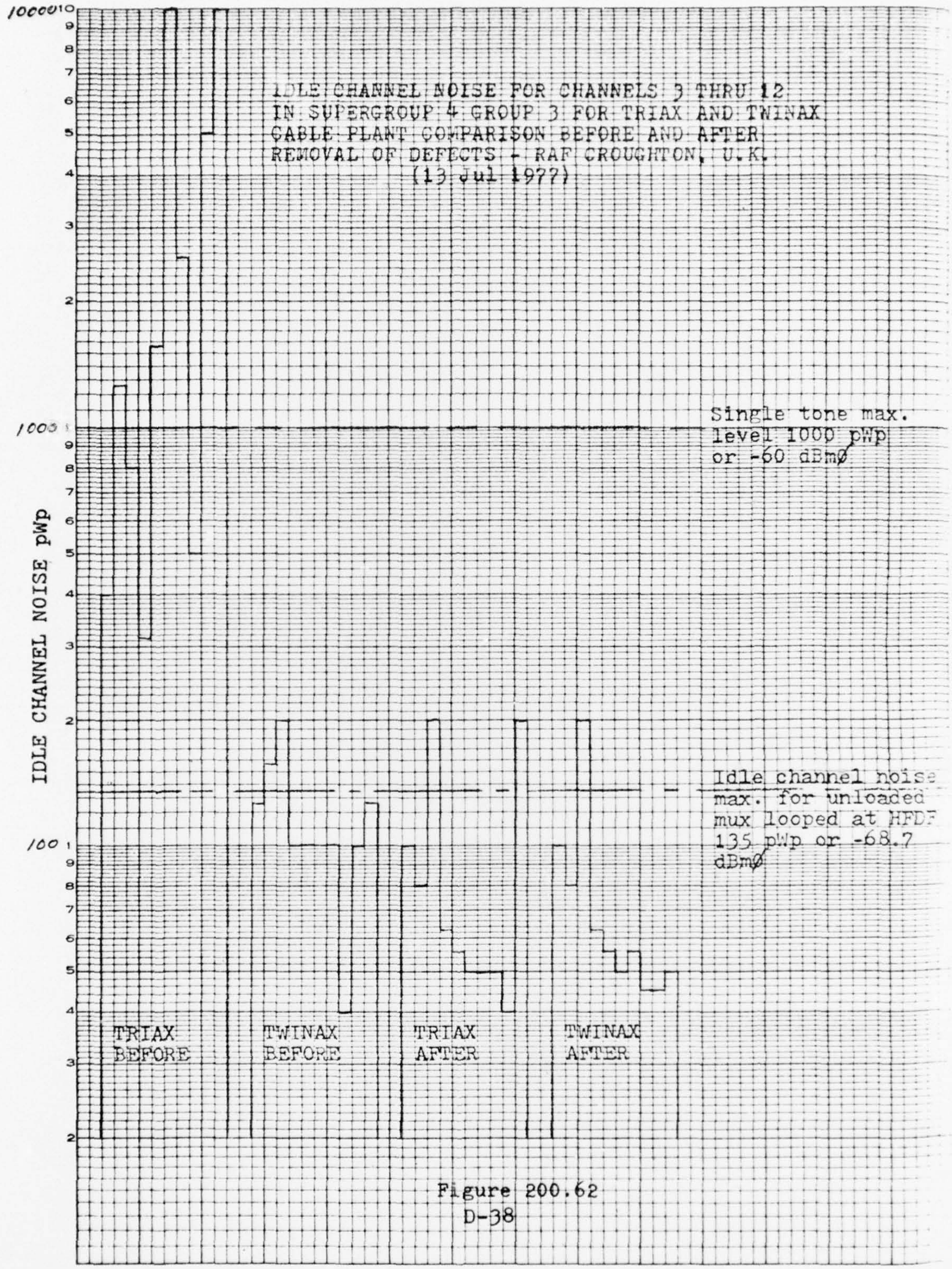

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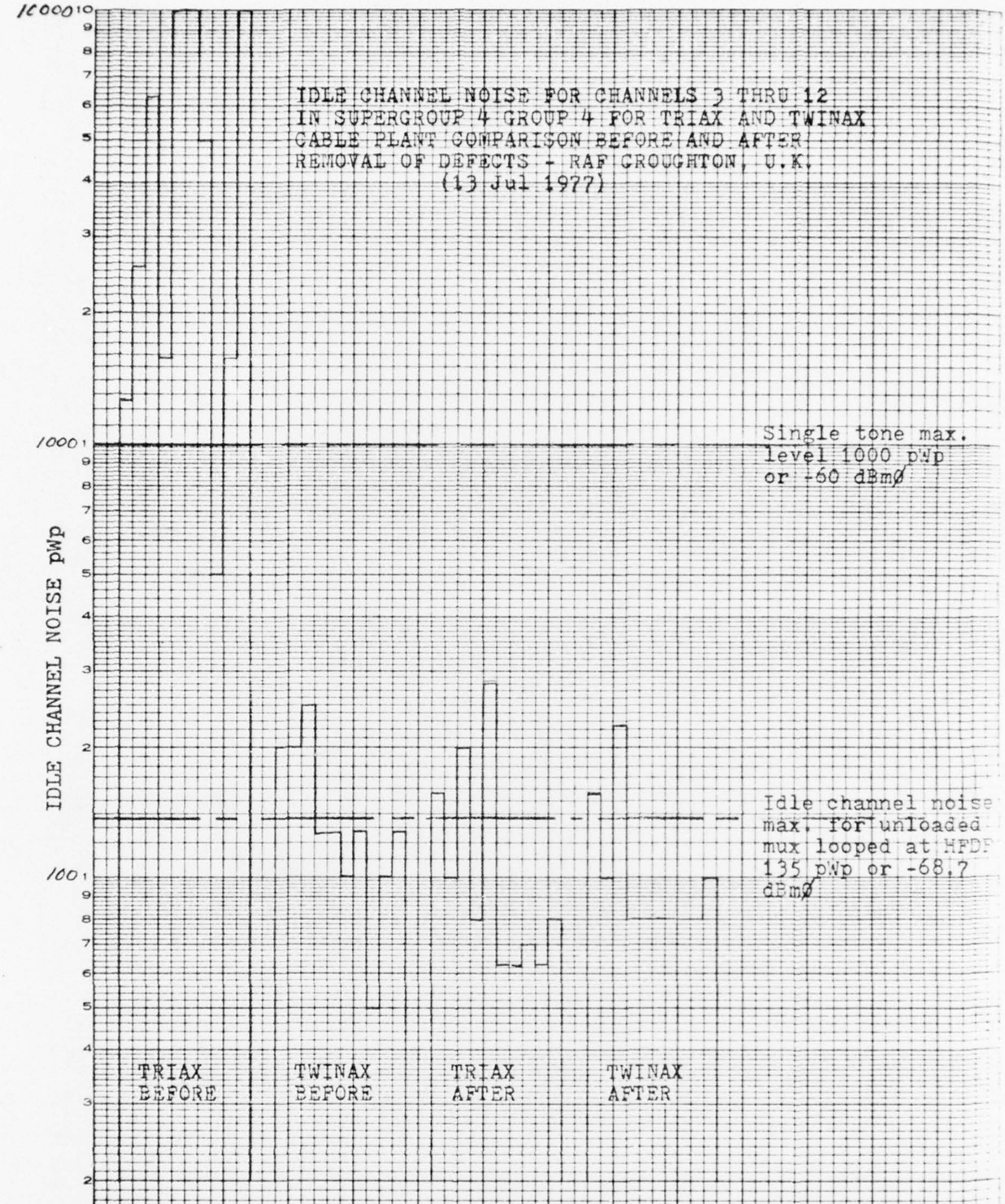

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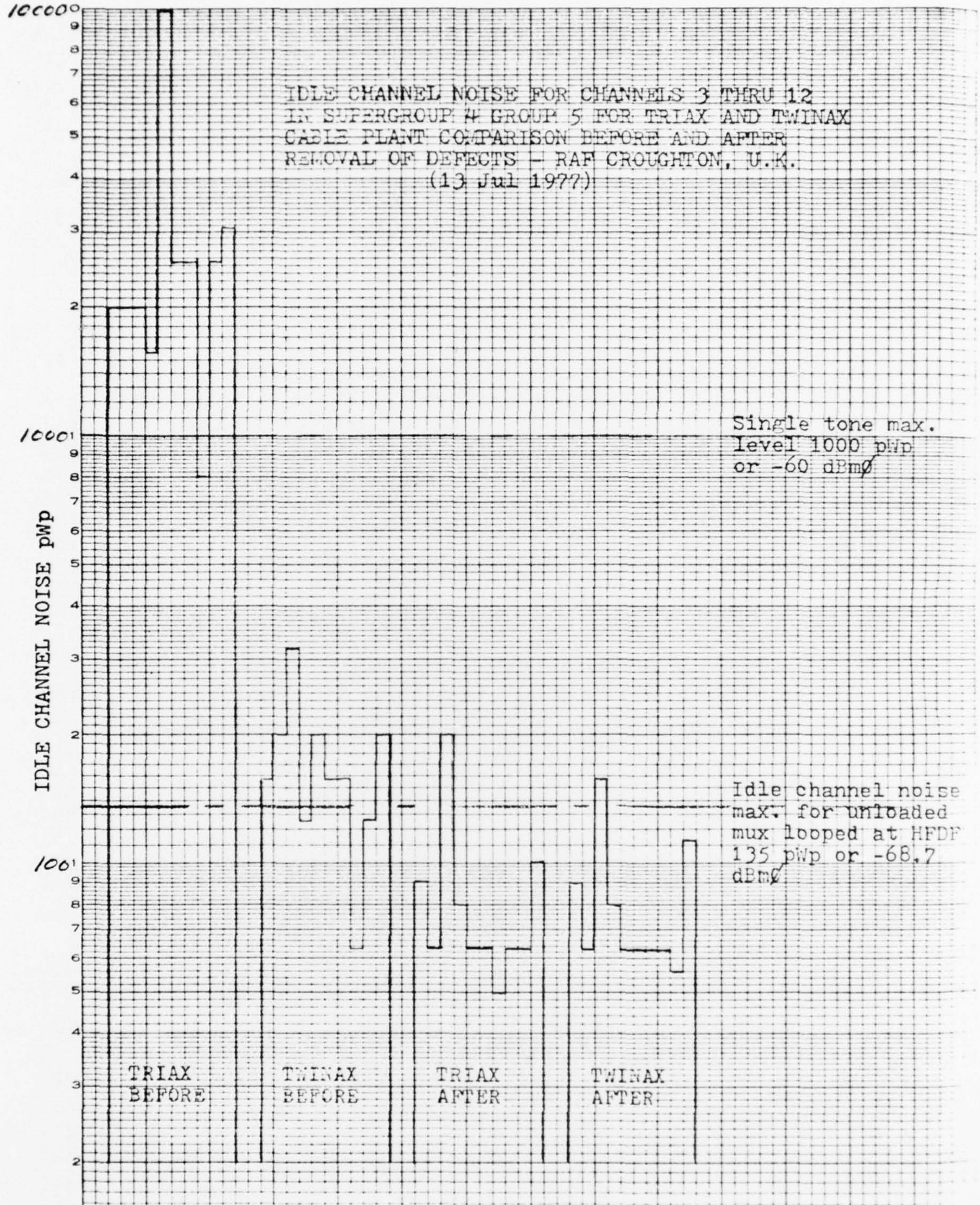

Figure 200.64

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